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# PROCEEDINGS

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## 26th Ontario Industrial Waste Conference

June 17 - 20, 1979  
The Prince Hotel  
Toronto, Ontario

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1979  
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Ontario

Ministry  
of the  
Environment

Hon. Harry C. Parrott, D.D.S.,  
Minister

Graham W. S. Scott,  
Deputy Minister

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**Proceedings  
of the  
Twenty-sixth  
Ontario Industrial Waste Conference**

**held at**

**The Prince Hotel  
Toronto, Ontario**

**June 17 - 20, 1979**

**Sponsored by the  
Ontario Ministry of the Environment**

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# CONTENTS

|                                                                                                                                                                                                                                                                                                                                        |     |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| <b>Preface</b> —J. W. Giles, Conference Chairman and<br>Assistant Deputy Minister,<br>Environmental Assessment<br>and Planning,<br>Ontario Ministry of the Environment                                                                                                                                                                 | IV  |
| <b>Conference Planning Committee and<br/>Technical Program Committee</b>                                                                                                                                                                                                                                                               | V   |
| <b>Pictorial Page—Session I Chairman and Speakers</b>                                                                                                                                                                                                                                                                                  | 1   |
| <b>What Price Environmental Purity?</b><br>Dr. D. M. Young,<br>Manager, Environmental Affairs<br>Dow Chemical of Canada Ltd.<br>Sarnia, Ontario                                                                                                                                                                                        | 3   |
| <b>Environmental Health-Risk Assessment</b><br>E. Somers, Environmental Health<br>Directorate, Health Protection Branch,<br>Department of National Health & Welfare,<br>Ottawa, Ontario                                                                                                                                                | 15  |
| <b>Environmental Assessment of the Uranium<br/>Mining Expansion in Elliott Lake</b><br>Dr. D. M. Gorber, General Manager,<br>Water and Waste Management<br>James F. MacLaren Limited, Toronto                                                                                                                                          | 37  |
| <b>Pictorial Page—Session II Chairman and Speakers</b>                                                                                                                                                                                                                                                                                 | 59  |
| <b>Water Management in Ontario</b><br>S. F. Salbach, Supervisor<br>Planning & Coordination Section<br>Water Resources Branch<br>Ministry of the Environment, Toronto<br><br>R. Peter Dennis, Head<br>Policy Planning & Development Unit,<br>Water Resources Branch<br>Ministry of the Environment, Toronto                             | 61  |
| <b>Biological Studies of the St. Clair River</b><br>S. Thornley, Regional Biologist<br>Southwestern Region<br>Ministry of the Environment, London, Ontario                                                                                                                                                                             | 73  |
| <b>Use of Low-Grade Heat for Electrical<br/>Generating Stations</b><br>Dr. W. R. Effer, Manager, Environmental<br>& Assessment Department<br><br>A. G. Barnstaple<br>Supervising Design Engineer<br>Process Development<br>Power Equipment & Engineering Studies<br>Design and Development Division<br>Ontario Hydro, Toronto, Ontario | 91  |
| <b>The Design and Commissioning of the<br/>Wastewater Treating System<br/>at Texaco's Refinery Nanticoke</b><br>R. D. Cameron<br>Environmental Engineer<br>Texaco Canada Inc., Nanticoke, Ontario                                                                                                                                      | 115 |

|                                                                                                                                            |     |
|--------------------------------------------------------------------------------------------------------------------------------------------|-----|
| <b>Pictorial Page—Session III—Chairman and Speakers</b>                                                                                    | 149 |
| <b>Environment Ontario's Seven-Point Program<br/>for Control of Liquid Industrial Wastes</b>                                               | 151 |
| The Honourable Harry C. Parrott, DDS,<br>Ontario Minister of the Environment                                                               |     |
| <b>Ontario Industrial Waste Disposal—<br/>Guidelines, Regulations and Related Activities</b>                                               | 165 |
| L. F. Pitura, Director<br>Waste Management Branch<br>Ontario Ministry of the Environment<br>Toronto, Ontario                               |     |
| <b>A Journalist's View of Industrial Wastes</b>                                                                                            | 175 |
| Ross Howard, Reporter<br>The Toronto Star, Toronto                                                                                         |     |
| <b>The Association's View on the Ontario<br/>Program</b>                                                                                   | 187 |
| A. Schudt, Representative<br>The Canadian Manufacturers Association<br>Toronto, Ontario                                                    |     |
| <b>A Citizen's Concern on Industrial Waste<br/>Pollution</b>                                                                               | 199 |
| W. Glenn, Pollution Probe,<br>Toronto, Ontario                                                                                             |     |
| <b>Pictorial Page—Session IV—Chairman and Speakers</b>                                                                                     | 201 |
| <b>The Federal Approach to Hazardous Waste<br/>Management</b>                                                                              | 203 |
| T. E. Rattray, Director, Waste Management<br>Branch<br>Environment Canada, Ottawa, Ontario                                                 |     |
| <b>Siting of Hazardous Waste Management<br/>Facilities</b>                                                                                 | 205 |
| C. A. Johnson, Technical Director<br>National Solid Waste Management<br>Association, Washington, D.C.                                      |     |
| <b>Transportation of Hazardous Materials</b>                                                                                               | 217 |
| J. M. Gaudreau, Chief of Operations<br>Division for Transportation of Dangerous Goods<br>Transport Canada<br>Ottawa, Ontario               |     |
| <b>Perpetual Care for Waste Management<br/>Facilities</b>                                                                                  | 221 |
| W. Williamson, Manager<br>Waste Utilization Section, Waste Management<br>Branch<br>Ontario Ministry of the Environment<br>Toronto, Ontario |     |
| <b>Pictorial Page—Session V—Chairman and Speakers</b>                                                                                      | 223 |
| <b>Waste Water Management Strategy for a<br/>Manufacturer of Halogenated Organic<br/>Chemicals</b>                                         | 225 |
| G. Campbell, Manager, Process Technology<br>Hydrosience, Inc., Westwood, New Jersey                                                        |     |

|                                                                                                                                                |     |
|------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| <b>Removal of Heavy Metals from Tailings<br/>Recycle Water at Mattabi Mines Ltd.</b>                                                           | 243 |
| R. Bourke, Project Engineer<br>Mattabi Mines Ltd., Ignace, Ontario                                                                             |     |
| D. Kemp, Design Engineer<br>Engineered Products and Systems<br>Power Plant Supply Company<br>Division of F. Hopkins Limited, Oakville, Ontario |     |
| <b>Coal Ash Management in Ontario Hydro</b>                                                                                                    | 269 |
| J. H. P. Buckingham<br>Ash Management Supervisor<br>Ontario Hydro, Toronto                                                                     |     |
| <b>Performance Report on a New Heavy Metals<br/>Removal System via Sulfide Precipitation</b>                                                   | 301 |
| S. R. Korchin<br>Market Specialist<br>The Permutit Company Inc.<br>Paramus, New Jersey                                                         |     |
| <b>Introducing the TAGA 3000</b>                                                                                                               | 327 |
| Dr. N. M. Reid<br>Vice-President, Research & Development<br>Sciex Inc.<br>Thornhill, Ontario                                                   |     |
| <b>Perpetual Care for Waste Management<br/>Facilities</b>                                                                                      | 329 |
| Task Force Report                                                                                                                              |     |

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## **PREFACE TO THE PROCEEDINGS OF THE 26th ONTARIO INDUSTRIAL WASTE CONFERENCE**

As Chairman of the Conference Planning Committee, I extend my appreciation to all those who contributed to the success of the 26th Ontario Industrial Waste Conference. The speakers took the time to prepare and deliver thought-provoking papers; the session chairmen kept sessions rolling; the delegates had the chance to participate fully in the timely and topical program developed by the imaginative members of the Technical Program Committee. The combination of all of these ingredients resulted in a worthwhile conference. Total registration was 549, the fourth consecutive year that attendance has passed the 500 mark. An all-time single day registration record was set for Tuesday session with 340 delegates attending the waste management discussions.

To the dedicated Planning Committee, without which there would be no Conference, I extend special thanks.

We believe that the Conference provides a service to the industrial community. New ideas, successful abatement programs, and experimental attempts at solving industrial waste problems are aired. We hope that everyone attending the Conference is challenged to contribute to the improvement of our environment. As long as this objective is being fulfilled there is good reason to continue these conferences.

On behalf of the Ontario Ministry of the Environment, thank you for participating. The following Proceedings will provide you with a record of what transpired. The 1980 Waste Conference, the 27th, will again be held at the Prince Hotel in Toronto. The dates for 1980 are June 15-18. You and your associates are invited to attend.



J. Walter Giles,  
Conference Chairman

## CONFERENCE PLANNING COMMITTEE



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Minister, Environmental Assessment  
and Planning, Ontario Ministry of  
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- J. R. Hawley, Head, Mining and Metallurgy Unit, Pollution  
Control Branch, Environment Ontario

## SESSION 1

### CHAIRMAN



**Dr. A. M. Scott, MD**

Medical Co-Ordinator, Industrial Hygiene  
The Steel Company of Canada Limited  
Hamilton, Ontario



### **What Price Environmental Purity?**

**Dr. D. M. Young,**  
Manager, Environmental Affairs  
Dow Chemical of Canada Ltd.  
Sarnia, Ontario

### **Environmental Health-Risk Assessment**

E. Somers, Environmental Health  
Directorate, Health Protection Branch,  
Department of National Health & Welfare  
Ottawa, Ontario



### **Environmental Assessment of the Uranium Mining Expansion in Elliott Lake**

**Dr. D. M. Gorber, General Manager,**  
Water and Waste Management  
James F. MacLaren Limited, Toronto



## WHAT PRICE ENVIRONMENTAL PURITY?

by

D. M. Young

Dow Chemical of Canada, Limited

### Zero Discharge

In principle, there are no technological barriers to the attainment of zero discharge to air or water, but costs become exorbitant as the level of contaminants is reduced. According to EPA estimates,<sup>1</sup>

"as a general proposition 85% reduction costs only 20% as much as 100% reduction. To go from 95% treatment to 98% treatment costs the same amount as going from 85% to 95% treatment. And to reduce another percentage of wastes costs the same amount. The last percent of reduction often costs as much as the first 99%."

Simple thermodynamics tells us that, even for 100% efficient processes, the energy required to reduce a pollutant concentration by a factor of ten is the same, whether it be from 10% to 1% or from 10 ppb to 1 ppb. In addition, as the driving force decreases at lower concentration, so also does the efficiency. We end up pumping huge quantities of fluid around to take out minuscule amounts of contaminants. Eventually, we reach a limiting dilution which calls for a more sophisticated technology - and a quantum leap in cost.

A good analogy is the problem of pumping all the gas out of a closed vessel.<sup>2</sup>

A rotary oil pump will reduce the pressure from 760 to  $10^{-3}$  torr, addition of a vapour diffusion pump reduces it to  $10^{-6}$  torr, addition of a "getter-ion" technique reduces it to  $10^{-11}$  torr, and cryosorption at  $15^{\circ}$  K produces an ultimate pressure of  $10^{-12}$  torr. The first (and cheapest) stage of pumping removes 99.9999% of the gas in the vessel!

"Zero discharge" is an expression beloved by environmental puritans. It has a nice, crisp ring to it, it's easy to spell and short enough to write on a political placard. Obviously, those who propagate this concept do not understand the philosophical implications of zero. Our environmental policy makers don't understand it either. For example, the 1978 Great Lakes Water Quality Agreement, Annex 1, sets forth the following objective for "unspecified organic compounds" (and I quote)<sup>3</sup>

"For other organic compounds, for which Specific Objectives have not been defined, but which can be demonstrated to be persistent and are likely to be toxic, the concentrations of such compounds in water or aquatic organisms should be substantially absent, i.e. less than detection levels as determined by the best scientific methodology available" (unquote)

Note that it states "best available", not "best practicable" methodology.

Our ability to detect trace contaminants will always exceed our ability to remove them. In the laboratory we can expose a minute quantity of sample to the most powerful, technologically advanced analytical hardware without regard for cost, time, or energy consumption. This high technology is not available to the plant engineer, who is limited to practical, cost-effective ways of removing

contaminants from process effluents.

As analytical capability improves, I am sure we shall find that, in the real world, everything is contaminated by an ever-so-small amount of everything else. You don't have to be a scientist to understand this. It was clearly perceived by Shakespeare<sup>4</sup> when he said:

"But no perfection is so absolute

That some impurity doth not pollute."

Environmental quality objectives should be expressed as some fraction of the level at which environmental damage is likely to occur. The pursuit of purity for its own sake, without regard to environmental and social benefits, is a gross misapplication of funds and effort.

#### Pollution by Pollution Control

Pushing pollution control to the limit of technology not only wastes a lot of money, but consumes a lot of energy and can have a negative impact on the environment as a whole. The very process of pollution control itself produces pollution. We cannot destroy matter; we can only convert it into a more acceptable, a more manageable form. To do this, we need land, equipment, energy, treatment chemicals, and a suitable grave for the end-product. Antonucci & Schaumburg<sup>5</sup> of Oregon State University made a detailed study of the total environmental impact of a highly advanced new sewage treatment plant at South Lake Tahoe in California. The tertiary stage involved lime coagulation and precipitation, air stripping, several stages of filtration/coagulation, activated carbon treatment and finally chlorination. The authors' conclusion (and I quote);

"The advanced wastewater treatment facility at South Lake Tahoe

effectively removes organics and nutrients from domestic wastewater. It was found, however, that the application of these sophisticated treatment operations requires a significant input of energy and treatment chemicals. Furthermore, several types of contaminants are discharged to the land and air phases of the environment as a result of the treatment operations.

There are also secondary or indirect impacts associated with the production of treatment chemicals and the generation of energy by various support industries that are attributable to wastewater treatment at South Tahoe.

Even though quantitative data are provided for energy and materials consumption and contaminant emission, it is not yet possible to determine whether advanced waste treatment processes effectively reduce the net level of degradation in the total environment. ...."

Schaumberg<sup>6</sup> notes that, because of thermodynamic limitations, the application of "add-on" treatment technologies rapidly approaches a point of diminishing returns. He advocates the effective use of "the cleansing facilities of nature" and a decrease in the rate of production of contaminants.

#### Cost/Benefit Analysis

How can society determine what is an acceptable level of pollution control? Let's look at the way we control other risks to public health and safety.

We accept a certain number of traffic accidents, drownings, burglaries, fires, plane crashes and work-related accidents as the inevitable by-product of the lifestyle we have chosen. Some of these hazards we can avoid by adopting a cautious, conservative lifestyle. Some we cannot avoid. We have to accept the risk of being run over because we need to cross the street; our forbears faced the dangers of runaway horses.

In principle, we could eliminate some of these hazards, but the social and economic cost is more than we are prepared to pay. We could eliminate crime, for example, by having a police officer at every street corner, but the tax burden would be staggering. So we compromise. We provide what we consider a reasonable degree of police protection and tacitly accept a certain level of crime. We are not saying that we're in favour of crime, merely that it's a losing proposition to clean it up completely. This is our cost/benefit judgment, to let a modest but efficient police force control the worst criminal excesses and we'll take our chances with what we can't afford to control.

The same strategy is adopted when a public hazard arises from the activities and products of private industry. Consider the automobile. We could virtually eliminate traffic deaths by instituting a nationwide speed limit of 10 m.p.h. (the first horseless carriages in Britain had to be preceded by a pedestrian carrying a red flag). An alternative approach would be to force manufacturers to use best available technology to make "safe" cars, but few people would be able to afford them or would want to use them (the passengers face backwards). What actually happened was that government regulations produced a modest improvement in safety - some better design features such as

the padded, crushable dash, stronger windshields, seat belts (which many people don't use), all at an extra cost of about \$350 per car. Clearly, society has rejected the "safe" car and opted to take its chances with a modest improvement in built-in safety features. This is society's cost/benefit judgment.

It makes no difference whether the hazard arises in the public or private sector, the bottom line is the cost/benefit ratio, whether those costs are accepted in the form of higher taxes to cover remedial action by government, or higher prices to cover industry's cost of complying with regulations. Either way, the public foots the bill and has a say in the matter, registering its opinion in the polling booth or through its purchasing power.

Environmental concerns are handled differently. They enjoy a special status and appear to be immune from the rigors of cost/benefit analysis to which other public issues are routinely subjected. This attitude is a residue from the sixties and early seventies when environmental clean-up was an activist crusade. We still hear the strident voices of the activists, but the issue of environmental protection has matured from a fashionable cause to an established societal goal. It should be taken off its pedestal and given a place with all the other legitimate but less glamorous public concerns. It is a benefit the public wants and is prepared to pay for. We must order our priorities so that the public gets good value for its money.

Cost/benefit analysis is limited in its usefulness by our unwillingness to put a dollar value on human life, health and well being. The very idea is repugnant, yet such evaluations are implicitly made in public affairs.

One indicator of the value of human life is how much society is prepared to spend to prevent one accidental death. In 1977, accidents at railway crossing in Canada<sup>7</sup> killed 87 people and injured 453, all preventable if we built overpasses, but the cost is considered excessive. The Pape Avenue crossing in Toronto claimed seven lives before the street was blocked and a pedestrian bridge built over the tracks (this was a compromise solution, a road overpass was considered too expensive). In Sarnia, an intersection across Highway 402 claimed six lives before an overpass was constructed in 1967 at a cost of \$750,000. We cannot avoid pricing the priceless.

The environmental decision maker must enter the subjective arena of practical politics. His dilemma in trying to quantify benefits is compounded by the fact that those who benefit are not saddled with the costs - not directly, that is to say. Only in four extreme cases is the decision clear-cut:

- Where there is no discernible benefit
- Where the benefit is so valuable that it overrides considerations of cost
- Where the cost is so minimal that it is not worth arguing the merits of control
- Where the cost of control is so punitive that it would force a plant shutdown

### Risk Perception

We've talked about the benefits arising from pollution control measures. We must also look at the other side of the coin and consider the consequences of

taking no regulatory action, that is, the risk to public health and the environment associated with existing and projected emissions. Statisticians can estimate with reasonable objectivity the risks of death, injury or disease associated with various activities. These risk numbers make fascinating reading, but they are only a guide to the decision maker, who has to determine what level of risk is acceptable to the public.

Here the decision maker is faced with two further problems. First, the public has shown that it is prepared to accept a much higher level of risk if it is self-imposed, as in smoking, than if it is involuntary, as in breathing polluted air. Secondly, the actual risk is not nearly as important as the public's perception of the risk. (The dentist who says "this won't hurt" is rarely believed). It is not enough for the politician to protect the public from statistically quantified risks - he must also be sensitive to the public's fears and feelings - and fantasies.

We are the first to criticize politicians for basing their decisions more on political sensitivity or "gut feel" than on scientific facts. But it is sobering to reflect that if scientists and engineers responded rationally to hard scientific data, we'd have no need for ashtrays in this hall.

The intrusion of politics into risk assessment can produce some bizarre results. Bob Hope quipped<sup>8</sup> that the United States is "the only country in the world that's about to ban saccharin and legalize marihuana". He forgot about Canada. The politician has to balance a large number of objective and subjective inputs, assigning a different weight to each. As the American historian Henry



Adams observed: "practical politics consists in ignoring facts". This balancing act involves a high degree of intuitive judgment and the courage to make a decision even though not all the facts are available. The special hazards of political office are reflected in the short professional life expectancy of cabinet ministers.

### Cost-Effectiveness

Once a decision has been made to control emissions, we have to select an appropriate control strategy. The key is to maximize cost-effectiveness by spending money where it will do the most good. The best results are obtained with new plants because the process engineer knows the rules in advance and can incorporate pollution control as an integral part of the plant design.

It makes much less economic sense to insist that older plants meet present-day standards by retrofitting pollution control devices. This is like changing the rules long after the game has started. It can be very costly. In most older plants, process effluent is mixed with once-through cooling water in a common discharge pipe. Sewer separation is necessary before the process effluent can be effectively treated. Older plants were built closer together than is the practice today, so there is often no available real estate for installing lagoons and treatment systems. It makes no sense to invest huge sums of new capital to upgrade a plant which may be obsolete in design, inadequate in capacity and profitable only because it is fully depreciated.

At some point we must decide either to shut an older plant down or to allow it to continue under a "grandfather clause" until the end of its normal commercial life. Rapid advances in technology and changes in business conditions

will ensure an orderly retirement of these older plants and their replacement by modern units incorporating the latest control technology. The competitiveness of Canadian industry supports our high standard of living and should not be thoughtlessly jeopardized through an excess of environmental zeal.

#### General Conclusions

- Environmental standards should be no more stringent than is required to protect public health and well-being and the environment.
- Environmental protection should take its place with other societal concerns and be subject to the same cost/benefit analysis.
- New industrial plants should be expected to meet tough but realistic environmental standards by incorporating best practicable technology at the design stage.
- Standards for existing plants should be set taking into account the age of the plant and the low cost-effectiveness of retrofitting pollution controls.

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4. Shakespeare, W., "The Rape of Lucrece", line 850.
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ENVIRONMENTAL HEALTH - RISK ASSESSMENT

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Environmental health in the most general sense covers all threats to human health from exogenous factors, not only extrinsic physical and chemical agents, but also lifestyle factors such as diet and sunbathing. We are well aware that our rapidly developing technological society poses potential and actual threats to human health and I would suggest that the evaluation of these threats in the total context of the problem is one of the key issues facing the political and administrative machineries of the modern state. According to current estimates some 60 000 natural or synthetic chemicals are used in daily life: about 1 000 new compounds are manufactured and used in industrial processes each year. Many of these chemicals, or their residues, appear in the work place or in air, water, food, and soil as contaminants from the production ~~or~~ consumption processes.

Similarly, the range of manufactured products - for professional or consumer use - is expanding with many of these products utilizing the latest electronic developments. The search for replacements for fossil

fuel sources has led to public scrutiny in many countries - sometimes with serious political consequences - of the hazards of nuclear energy. Particular emphasis has been given to the long-term biological effects of ionizing radiation.

I would suggest that there are four basic mechanisms available for society to deal with these real and presumed hazards: economic, educational, socio-cultural, and regulatory. In terms of this Symposium, it is appropriate to consider the latter only and I propose to describe the terms of federal authority - then give examples of our attempts at risk assessment for some environmental hazards. Finally, moving back from the specific to the general, I should like to review my appreciation of the implications of risk assessment.

The federal government's authority in the area of environmental health derives from its jurisdiction over criminal law, inter-provincial trade and commerce, and its residual authority to legislate for the "peace, order and good government of Canada". The major Acts of Parliament which confer powers to control and regulate health hazards caused by environmental insults are shown in SLIDE 1. The basic National Health and Welfare Act confers a general authority for investigation, research, and information collection. The Food and Drugs Act in addition to its obvious responsibilities also covers the sale of medical devices and cosmetics: although it could provide authority over the sale of drinking water traditionally and administratively this has always been regarded as the responsibility of the provinces. The Radiation Emitting Devices Act delegates authority to prescribe standards regulating the design,

construction, and functioning of devices to protect against personal injury. The Hazardous Products Act is concerned with protection against dangerous consumer products: microscope oils containing PCBs have been banned, standards set for toys, cooking utensils and so forth. The Environmental Contaminants Act provides regulatory control over the dispersal of substances in the environment that may constitute a danger to human health or the environment: information and tests on the pollutants can be required. Powers exist to make regulations prescribing the quantity of a substance that can be released to the environment: such regulations have been promulgated for the chlorobiphenyls and proposed for mirex, polychlorinated bi- and ter-phenyls.

These are the five basic Acts which determine our responsibilities. In addition, we have an advisory or consultative role in terms of risk to human health with the following Acts: Pest Control Products, Atomic Energy Control, Clean Air, and Canada Labour Code (Part IV).

I now would like to show how this legislative base has been used in recent years to control a number of environmental hazards. In particular, I will outline our attempts - albeit faltering - to provide the risk assessment that leads to regulatory control. Two recent SCOPE publications <sup>(1, 2)</sup> have defined the elements of risk assessment as: risk identification, risk estimation - a scientific determination in as quantitative manner as possible, and risk evaluation in which judgement is made on the acceptability of the risk and its consequences. This last component is concerned with comparing risks against one another, against

benefits, and with a judgement on the social acceptability of the risks.

We have just completed - through an extremely energetic federal/provincial working group - a comprehensive review and re-assessment of the 1968 Canadian Drinking Water Standards and Objectives. Trihalomethanes are known to occur in drinking water as a result of treatment by chlorine. The most commonly found trihalomethane in drinking water is chloroform and a recent survey <sup>(3)</sup> of some 70 Canadian municipalities showed that its concentration can reach 121 µg/L. Is this an acceptable level? Epidemiological studies, in the lower Mississippi and Ohio river valleys, have not shown unequivocal evidence of a direct cause-effect relationship between chloroform contamination in drinking water and a variety of recorded cancers. However, the NCI rodent study found a dose-related incidence of malignant tumours in the kidneys of male rats and the liver of mice of both sexes <sup>(4)</sup>. The daily dose to produce these effects was high - in the range 100-500 mg/kg body weight. In addition, studies with cough suppressants and mouth washes have shown that hepatotoxicity occurs in humans at oral doses of chloroform between 1 and 25 mg/kg/day (70 kg/person): occupational exposure to chloroform in the pharmaceutical industry is known to produce liver damage to the workers <sup>(5)</sup>.

Tardiff <sup>(4)</sup> has carried out a detailed analysis through four different models - margin of safety, and the statistical probit/log (Mantel-Bryan), linear or one-hit, and two-step - to determine the maximum risk incurred by drinking tap water containing chloroform. A tenfold margin of safety applied to liver damage in man gives a maximum daily dose of 0.03 mg/kg. Extrapolation from the rodent studies (SLIDE 2) shows the maximum risks at

a maximum daily dose of 0.01 mg/kg range up to 0.4/million/year. For a 70 kg man consuming 2 L of water daily this intake represents a chloroform concentration of 0.35 mg/L: this is the recommended maximum acceptable concentration of total trihalomethanes in drinking water: the objective level, i.e. the ultimate quality goal, is less than or equal to 0.0005 mg/L.

In this example, extrapolation from animal studies to man by means of statistical system is defensible because we know the human target organ for chloroform and there is some evidence of similar metabolic pathways. On this basis we can say that the risk of cancer to a member of the population from drinking water attributable to chloroform lies between no risk to kidneys and liver and a maximum of 1 in 2.5 million/year.

The maximum acceptable concentrations of some representative pesticides in drinking water are shown in SLIDE 3. Where a no-effect level has been observed and the subsequent Acceptable Daily Intake established by international agencies (WHO, EPA) the daily consumption of 2 litres of water containing the maximum acceptable concentration would result in the ingestion of less than 20% of the ADI. It can be seen that the acceptable margin of safety is at least 500-fold.

The detergent builder, nitrilotriacetic acid (NTA), is widely used in Canada with current consumption of more than 50 million pounds annually, most of which is disposed of in sewage. In studies with rats and mice it has been found that high doses of NTA give increased incidence of urinary tract tumours. In a recent national drinking water survey <sup>(6)</sup> we have found a mean concentration of 2.8 µg NTA/L. Assuming that man ingests 50 µg/L of NTA daily - a level greater than at least 99% of reported drinking water samples - and making no allowance for the reduced absorption of the compound by



humans as compared with rodents, the daily ingestion for a 70 kg man would be 0.001 mg/kg. Using the linear arithmetic model the probable maximum risk from this intake would be about 1 in 2 million. The safety factor for other effects - based on biochemical and histological changes - is about  $10^4$ . A maximum acceptable concentration of 0.05 mg/L has been recommended for NTA and an objective concentration below 0.0002 mg/L.

Asbestos, which is now clearly indicted as a human carcinogen, is extensively used in dry-wall patching products. Analytical studies (Rahl, see<sup>7</sup>) of the fibre concentrations of 10 dry-wall taping compounds during sanding, dry mixing and floor sweeping operations have shown average peaks as high as 47 fibre/cc. The U.S. Consumer Product Safety Commission has developed a risk assessment model based on a number of assumptions including: linear dose-response relationship between asbestos and lung cancer, time to tumour being dependent on dose, effect of dose is cumulative. These lead to a log dose-log response curve (SLIDE 4): the experimental data on cancer deaths attributable to dose are derived from Selikoff. Calculations of high intermittent exposure for four uses per year gives an exposure level equivalent of 0.4 fibres/cc/day for one year: this will cause an additional 10 lifetime respiratory cancer deaths/million. If effect of dose is cumulative and is assumed to have the same effect as if that dose had been accumulated in the year of exposure then continued use of asbestos for five years will raise that estimate to 990 deaths/million.

It will be crystal clear why the Department of National Health and Welfare has recommended that asbestos be banned in dry-wall patching compounds under the Hazardous Products Act. The Department of Consumer

and Corporate Affairs has already issued a trade information letter on this topic.

The Hazardous Products Act is to be used to control the hazard of nitrosamines in cutting oils in which ethanolamines used as emulsifiers can react with nitrite corrosion inhibitors. Fan et al <sup>(8)</sup> reported up to 3% N-nitrosodiethanolamine in cutting oils: we found in an analysis of 24 samples, eight contained up to 4 000 ppm of this compound. Although N-nitrosodiethanolamine has a lower toxic potential than other nitrosamines all animals developed liver tumours (100-200 mg/kg/day) <sup>(9)</sup>. We do not know the extent of workers' exposure to this nitrosamine, via inhalation or dermal routes, but the level and severity of presumed risk was sufficient to actuate a proposed ban on the simultaneous presence of nitrites and ethanolamines in cutting oils. Similar considerations led to the ban on the use of Tris (2, 3-dibromopropyl) phosphate, a flame retardant for textile fabrics used for children's clothing. Tris, in its commercial form, has been found to be carcinogenic to rodents (N.C.I.), mutagenic to test systems, and be absorbed by the skin.

In the field of radiation protection, risk assessments rest on securer foundations in that the biological hazards of radiation on human populations have been well - and often tragically - demonstrated and the dose-effect relationships established. The Report of the Advisory Committee on Biological Effects of Ionizing Radiation (BEIR Report, 1972) and the Recommendations of the International Commission on Radiological Protection provide extremely detailed and well-constructed estimates of risk. Let me give examples of their use.

In 1972, a survey of ionizing radiation devices in Ottawa schools revealed a large number of machines used in demonstrations. Among these were unshielded cold cathode X-ray tubes whose maximum exposure at 30 cm was 4 to 35 Röntgen/hour. This could result in an average absorbed dose for children watching the demonstration of 1 rem. For each child, this can be translated into a risk of the development of a fatal cancer of one in  $10^4$  per year due to this single exposure. This was regarded as sufficient justification to regulate these devices and they had to be controlled at the manufacturing level. Regulations establishing standards of design, construction and functioning for demonstration-type gas discharge devices were promulgated under the Radiation Emitting Devices Act in February, 1976.

We have used this statistical approach to risk estimation to derive guidelines for radioactivity in drinking water. For most of the radionuclides in drinking water (Ra-226, I-131, Cs-137) there is a great deal of information on their metabolic fate after ingestion by humans. The known parameters on distribution and retention of a given radionuclide may be used to calculate an annual radiation dose over a life-time. Estimates from the BEIR Report give the excess annual number of cancer deaths for a population of one million exposed to radiation of 200 millirem per year as within the range 15 - 35. By combining the parameters for concentration-dose with the dose-health effects it is possible to derive a concentration-health effects relationship. We have derived guidelines for acceptable concentrations of radioactivity in drinking water at a given risk, namely one cancer per million people per year.

I have provided some examples of the manner in which a federal agency arrives at a risk assessment for an environmental hazard and then pursues control measures. Our society is increasingly concerned with the chronic, and often irreversible, effects of toxic chemicals and ionizing radiation - as opposed to acute effects. This is quite explicit in the approach outlined in the Federal Register (10) for implementation of the Toxic Substances Control Act, and in the controversy which is raging throughout the world on the expansion of the nuclear industry. Extrapolation to low doses is fraught with imponderable factors and the inappropriateness of equating physical radiation damage with the cell reactions of chemical carcinogenesis, or of assuming that biological effects are proportional to dose regardless of the size of dose or the rate of exposure is being vigorously debated today. Nevertheless, I would submit that these statistical techniques provide us with a tool to place risk estimation in the total context of the problem.

You will remember that the elements of risk assessment were defined as identification, estimation, and social evaluation. A particularly valuable technique for arriving at the latter judgement is to compare the risk either with other risks, or the presumed benefit. A schematic approach is shown in SLIDE 5 from Burton and Whyte <sup>(2)</sup>, that enables risk equations to be derived in the form: elevated risk, comparative risk, balanced risk, and risk-benefit. Elevated risk means comparison with the natural background - the level of 'noise' in the system. The contaminant may have always been with us - like mercury in fish, or fluoride in drinking water - and its beneficial or adverse effects tolerated. The natural background dose of ionizing radiation that we are subjected to is appreciable,

being of the order of 100 millirem per year, with the cosmic radiation component being doubled for those lucky enough to live in Denver. Our own studies <sup>(11)</sup> on some 10 000 Canadian homes has shown enhanced levels of radon and radon daughters - some 13% of homes had radon daughter levels over the 0.02 WL used as reference for uranium mining communities. The internationally accepted estimates of risks suggest that the number of cancers and genetic effects induced in the general population by natural background radiation are not more than about 1% of the numbers of cancers and genetic defects normally present in the general population <sup>(12)</sup>.

SLIDE 6 <sup>(13)</sup> from Pochin's report, gives the annual genetically significant dose rate as averaged through the whole population. You can see why proponents of nuclear power so often find the opposition inexplicable. The overall population exposure to radiation from the nuclear industry is only a small proportion of that received from natural sources. This slide also illustrates the comparative risk equation in that the nuclear risk is small compared with that received from the use of X-rays and radiological therapy in medicine. The medical, and allied, professions furnish the vast majority of our man-made dose of ionizing radiation - something that has caused much concern to health authorities <sup>(14)</sup>.

A common measure of risk comparison is the ultimate one-death. SLIDE 7, drawn again from Pochin <sup>(15)</sup>, provides an example of this approach which is often used in the comparison of occupations or modes of transport. Cohen <sup>(16)</sup> has great fun applying this technique to the risk of health from bladder cancer incurred from diet drinks containing saccharin: failure to install a smoke alarm is as dangerous as ingesting 3 diet drinks per day;

an average street crossing is about as dangerous as a diet drink. This is, of course, reductio ad absurdum but the sight of the ranking order can be salutary.

Balancing risks from alternatives has been quantified for energy production. Inhaber <sup>(17)</sup> has calculated man-days lost and total deaths for a variety of energy systems - SLIDE 8. Both for total deaths (public and occupational) and man-days lost per unit net energy output (one megawatt-year) the energy generated by natural gas had the lowest overall risk associated with it, followed by nuclear energy and ocean thermal. Although these conclusions have been criticized I submit that the analysis provides a logical approach when one has to weigh the risks from alternatives designed to achieve the same end-product, in this instance - energy.

The choice of alternatives is at the heart of the risk assessment process. The knowledge that other fire retardants for textiles were available influenced the decision to ban Tris. When cyclamates were withdrawn from the market, saccharin was available for diet drinks. If chlorination of water supplies is replaced by ozonization - what is the toxicity of the reaction products and what is the microbial quality of the treated water? As the BEIR Report set forth:

"The public must be protected from radiation but not to the extent that the degree of protection provided results in the substitution of a worse hazard for the radiation avoided".

The fourth way to compare risks is to compare them with the benefits they bring. As patients we accept the hazards of medicine, be they drugs, surgery, or X-rays, for the benefits they can bring. Pesticide risks to

ecological systems can be weighed against increased food production. Chlorination of drinking water indisputably protects against some most unpleasant water-borne diseases. Some of these benefits may be commonly accepted as outweighing the risks but we are now facing the basic problem of societal judgement. The seemingly objective techniques of cost-benefit, and decision analysis founder when faced with the reality of human values, aspirations, and even whims. Although society implicitly costs human lives in many of its decisions we cringe - and rightly so - from the abhorrent task of setting a monetary value on human life. In recent years this lesson has been learned the hard way in many countries where the ultimate political decision on risk acceptability has overturned costly and protracted analyses proposing airport sites or nuclear reactors. There is a spirit of distrust of high technology abroad <sup>(18)</sup>.

Over the last three years we have seen a plethora of literature on risk assessment - its techniques and its social acceptance. It was only in 1976 that Lowrance's book 'Of Acceptable Risk' <sup>(19)</sup> appeared and great strides have been made in erecting a rational frame from which to base decisions. As long as we recognize the limitations of our knowledge - that some of our extrapolations may well be beyond the practical application of the scientific method, termed 'trans-scientific' by Weinberg <sup>(20)</sup> - and that the regulatory decisions on environmental hazards are only as good as the political process which makes them - we will live to cope with this extraordinary technological society we are creating.

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MAJOR FEDERAL ACTS RELATING TO ENVIRONMENTAL  
HEALTH STANDARDS

ATOMIC ENERGY CONTROL

CANADA LABOUR CODE (PART IV)

CANADA WATER

CLEAN AIR

ENVIRONMENTAL CONTAMINANTS

FISHERIES

FOOD AND DRUGS

HAZARDOUS PRODUCTS

MOTOR VEHICLES SAFETY

NATIONAL HEALTH AND WELFARE

PEST CONTROL PRODUCTS

RADIATION EMITTING DEVICES

# MAXIMUM RISK FROM CHLOROFORM INGESTION

| MODEL                        | BASIS        | ESTIMATED<br>MAXIMUM RISK | MAXIMUM<br>DOSE<br>(mg/kg/day) |
|------------------------------|--------------|---------------------------|--------------------------------|
| PROBIT-LOG (SLOPE = 1)       | RAT: KIDNEY  | 0.016-0.040/M/YR          | 0.01                           |
| PROBIT-LOG (ACTUAL<br>SLOPE) | RAT: KIDNEY  | { <1/B/LIFETIME           |                                |
|                              | MOUSE: LIVER |                           |                                |
| LINEAR (ONE-HIT)             | RAT: KIDNEY  | 0.420/M/YR                |                                |
| TWO-STEP                     | RAT: KIDNEY  | { 0.28/M/YR               |                                |
|                              | MOUSE: LIVER |                           |                                |

M-MILLION : B-BILLION

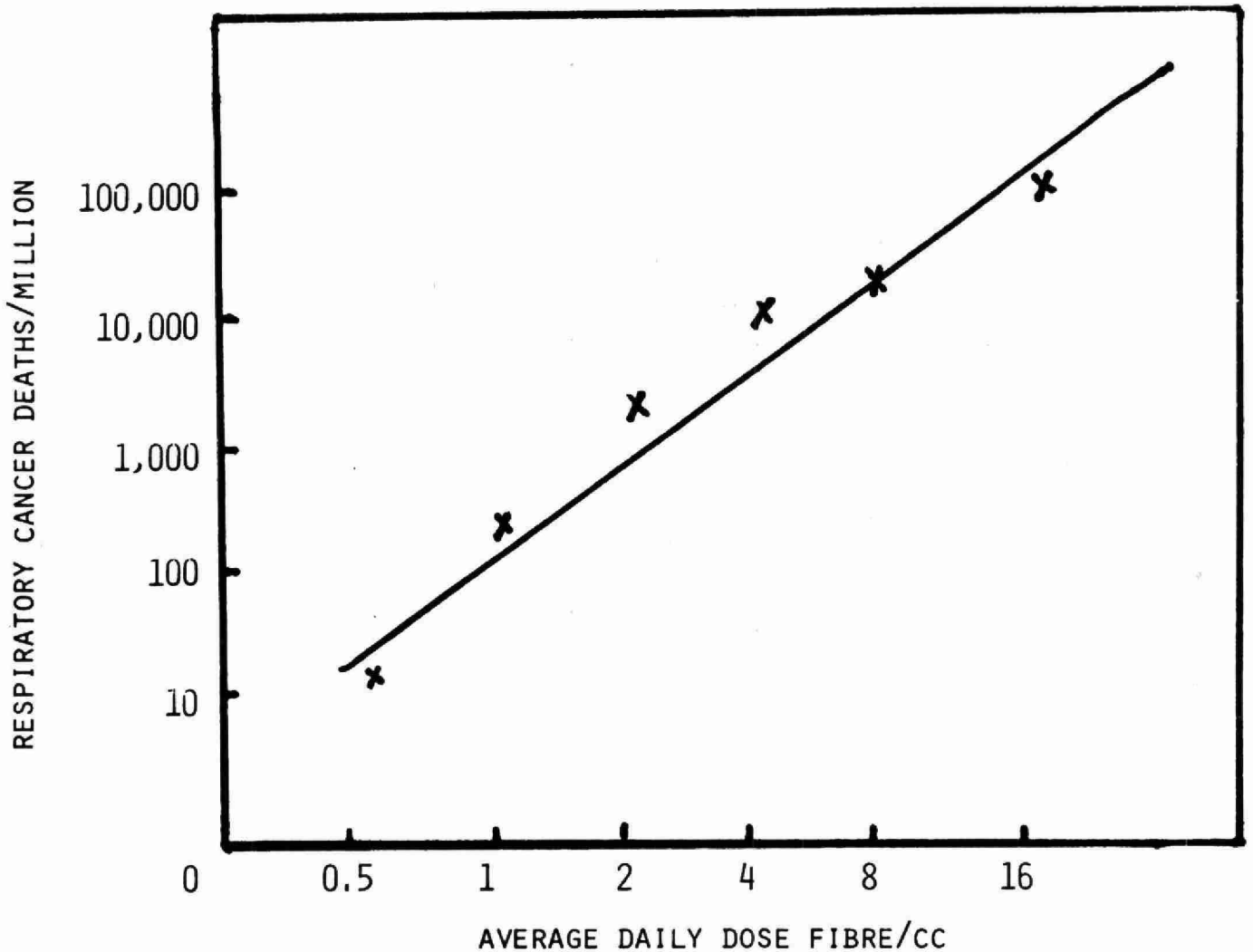
MAXIMUM ACCEPTABLE CONCENTRATION (M.A.C.)  
OF PESTICIDES IN DRINKING WATER

|              | NO-EFFECT<br>LEVEL<br>(mg/kg/day) | A.D.I.<br>(mg/day)<br>(70 kg man) | M.A.C.<br>(mg/l) | SAFETY<br>FACTOR |
|--------------|-----------------------------------|-----------------------------------|------------------|------------------|
| 2, 4 - D     | 8.0                               | 1.12                              | 0.1              | 500              |
| 2, 4, 5 - TP | 0.9                               | 0.14                              | 0.01             | 500              |
| ENDRIN       | 0.02                              | 0.0028                            | 0.0002           | 500              |
| METHOXYCHLOR | 17.0                              | 1.4                               | 0.1              | 850              |
| LINDANE      | 0.3                               | 0.042                             | 0.004            | 500              |

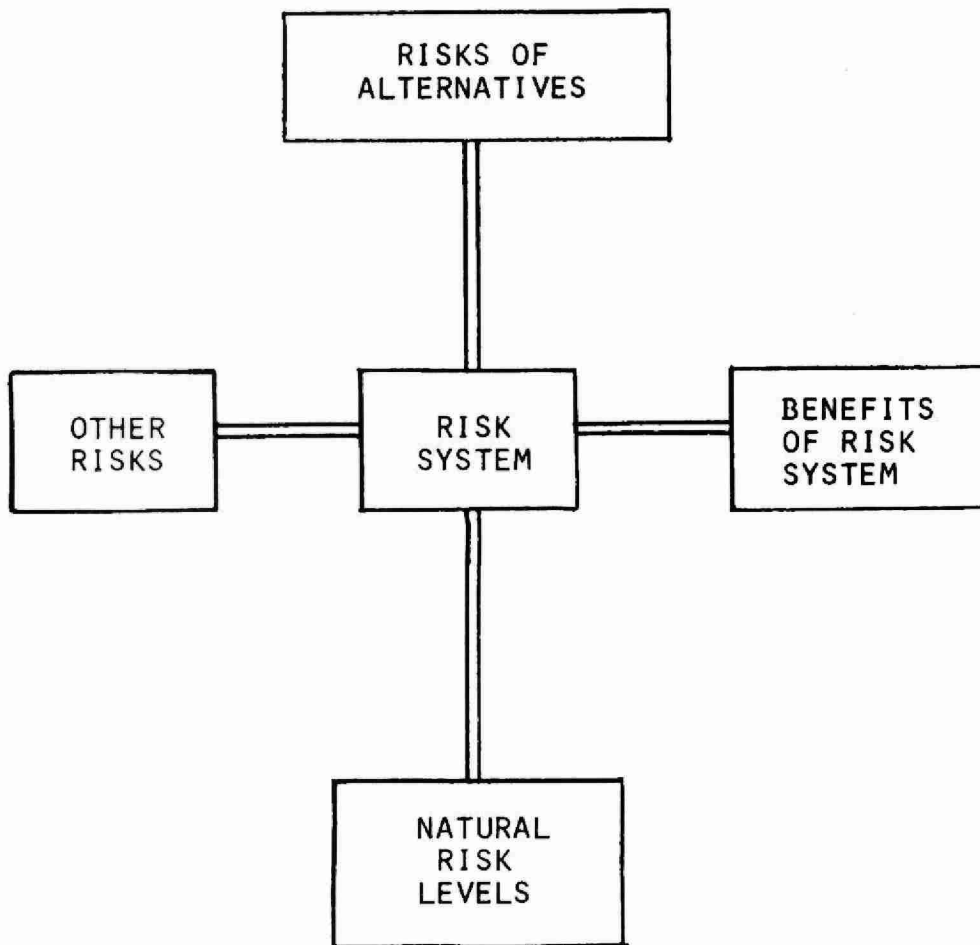
ASBESTOS INDUCED RESPIRATORY CANCER DEATHS PER  
MILLION, LIFETIME VS. DAILY EXPOSURES (FIBRE/CC)  
FOR ONE YEAR. ESTIMATES BASED ON THE MODEL:

$$\text{LOG } Y = 2.031 + 2.518 \text{ LOG } X$$

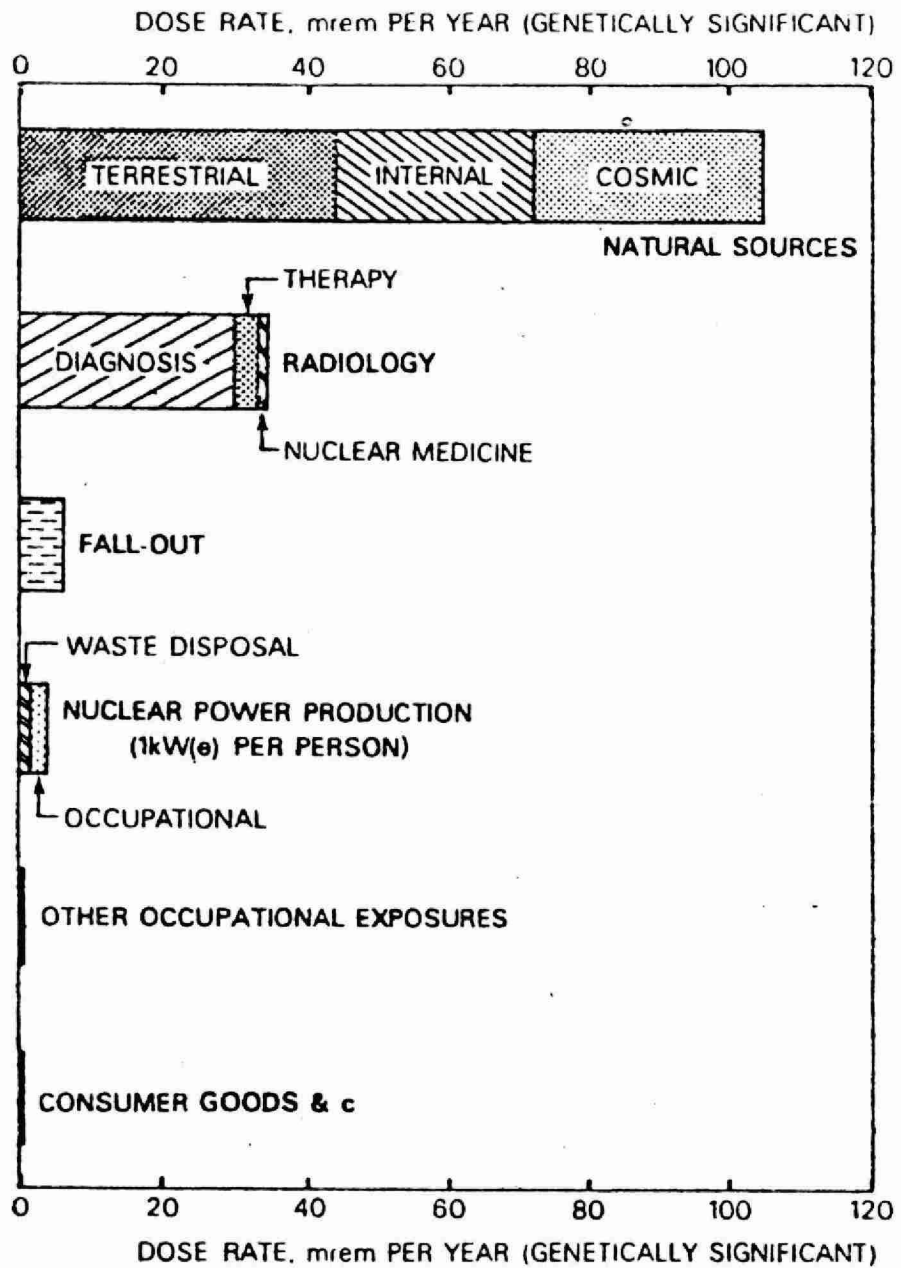
CORRELATION COEFFICIENT = 0.982



RISK COMPARISON



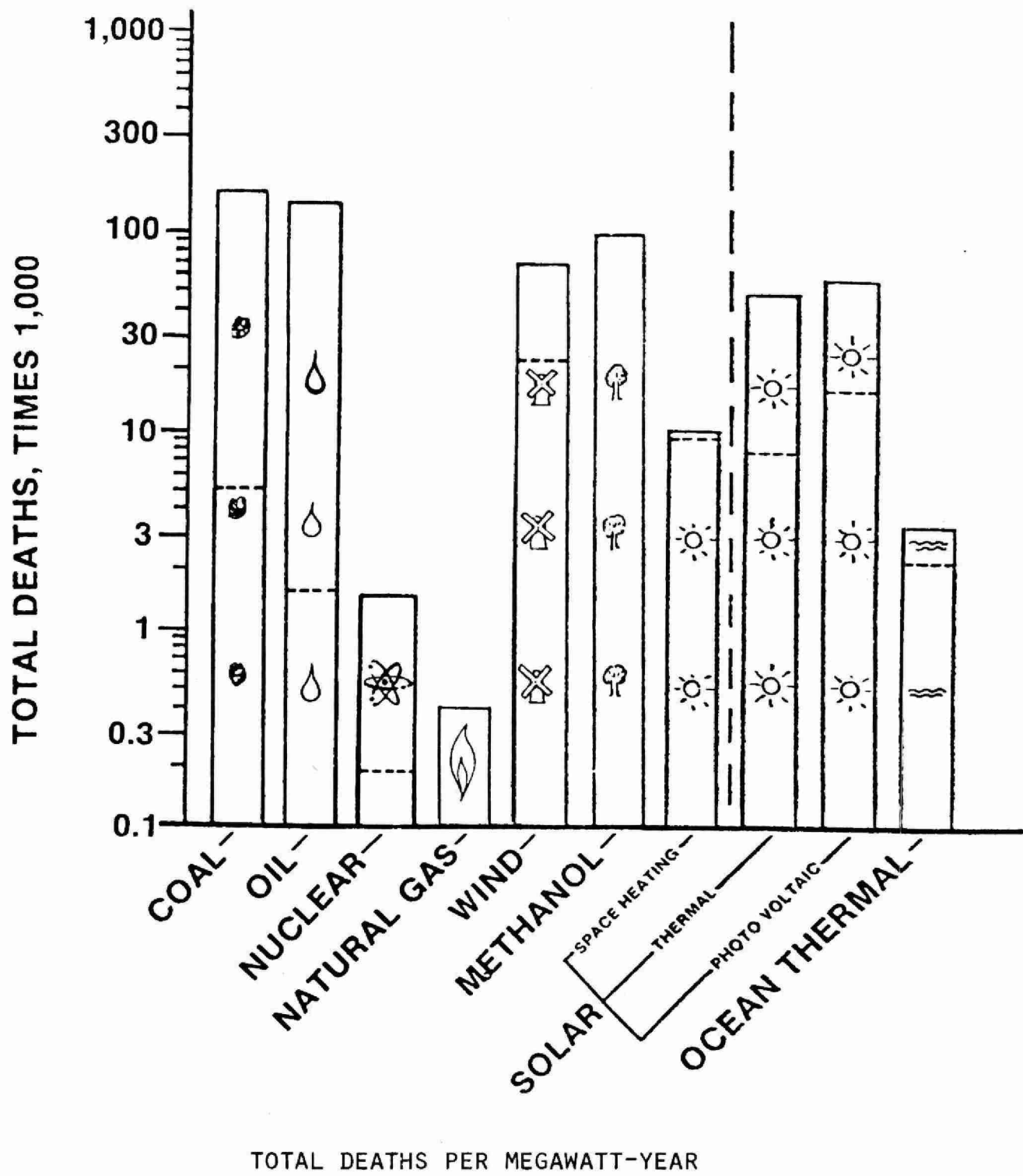
SLIDE 6



| COMPARATIVE RISKS*                          |             |                   |
|---------------------------------------------|-------------|-------------------|
| ACTIVITY                                    | CAUSE       | DEATHS/MILLION/YR |
| ROCK CLIMBING                               | ACCIDENTS   | 30-40             |
| COAL MINING (UK)                            | ALL CAUSES  | 300               |
| MINING (USA)                                | ACCIDENTS   | 1 000             |
| CANADIAN POPULATION <sup>†</sup><br>(1974)  | ALL CANCERS | 1 500             |
| URANIUM MINING (USA)                        | LUNG CANCER | 1 500             |
| ASBESTOS MANUFACTURING<br>(MALE SMOKERS UK) | LUNG CANCER | 2 300             |
| DEEP SEA FISHING                            | ACCIDENTS   | 2 800             |
| SMOKING 20 CIGARETTES<br>PER DAY            | LUNG CANCER | 5 000             |

\*POCHIN (1975)

<sup>†</sup>CAUSES OF DEATH 1974 (1976)





ENVIRONMENTAL ASSESSMENT OF  
URANIUM MINING IN ELLIOT LAKE

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Introduction

Early in the 1970's, Denison Mines Limited and Rio Algom Limited began preparations for the expansion of production at their Elliot Lake properties. In view of this expansion, the Ontario Minister of the Environment recommended that the Environmental Assessment Board be authorized and directed to hold a public hearing in respect of the expansion. The Committee of Council concurred and by order-in-council directed the Environmental Assessment Board to conduct public hearings.

Following a preliminary public hearing, the Board directed that the two uranium mining companies conduct a two-phase environmental assessment study. The first phase focussed upon the definition of changes attributable to the mining of uranium which has been ongoing since 1955. The subsequent report, submitted in March 1977, addressed environmental sectors such as the terrestrial, aquatic, atmospheric and biological components. Details of current mining, milling and waste management practices were also given.

The proceedings were temporarily adjourned in April 1977 to allow the Board members to consider the evidence and arguments presented. A subsequent 32-point Ruling delineated a wide range of both specific and general topics it wished to be included in the second phase of the study. The Ruling drew a number of new participants into the hearings, as

various ministries and agencies were requested to prepare or assist in the preparation of briefs and reports.

The hearings reconvened on an intermittent basis in the spring of 1978. To augment the witnesses of the full-time participants, a number of experts were summoned to address a variety of subjects. Included in their testimonies were descriptions of the development of water and air quality models, formulation of estimates of exposures for hypothetical individuals to radiation and analysis of public concerns and perceptions. Considerations related to the quality of the environment addressed in detail included the release and potential for minimizing the discharge of numerous compounds and radionuclides, the establishment of goals to provide for the restoration of local fisheries, the ramifications of radionuclides in food chains and the assessment of local radiological environments.

By the end of the hearings in February 1979, the Board had heard from approximately 100 witness who had produced more than 10 000 pages of testimony and filed more than 400 exhibits. In consideration of all of the evidence submitted, the Board issued its final report in May 1979 (EAB 1979). The report contained summaries of arguments presented at the hearing, and presented more than one hundred-fifty conclusions and recommendations addressing the spectrum of topics considered. This paper reviews the discussions related to a restricted few of the many issues brought before the Board. Included are discussions on the nature and effects of ammonia, nitrates, pyrites, various radionuclides and selected waste management options.

### Ammonia

Ammonia is used in mining and milling operations at Elliot Lake properties. Increases in levels in effluent streams and downstream lakes have resulted in concern about the

amounts of ammonia reaching the aquatic environment. Consequently, the Board requested that the mining companies investigate the potential for reduction of the release of ammonia by examining conditions at the mining and milling sources.

Ammonia levels in the lakes of the Serpent River Basin typically range from less than 1 mg/L-N in lakes lying towards the basins discharge to Lake Huron, to as high as 3 mg/L-N in a large lake immediately downstream of the operating properties.

In water, ammonia exists as dissolved molecular ammonia ( $\text{NH}_3$ ) and ammonium ion ( $\text{NH}_4^+$ ) forms in equilibrium. Only the molecular form is toxic, the ammonium ion having little or no toxicity (Downing and Merkeno 1955; E.I.F.A.C. 1973; Burkhatler and Kaya 1977). The percentage of molecular ammonia present is to a large extent a function of pH, as shown in Figure 1.

Fish in alkaline environments are susceptible to the toxic effects of molecular ammonia as conditions favour its formation (Rubin and Elmaraghy 1977). Due to the depressed pH conditions in the upper lakes of the Serpent River Basin, the existing ammonia concentrations have not presented a hazard. Should the pH rise to 7 or more, the present ammonia concentrations may adversely affect fish populations.

One source of ammonia has been mine water. In the mines, ammonium nitrate based explosives are used because of the relatively high degree of safety they provide. Part of this safety stems from the explosive's high degree of solubility allowing excess and spillage to be easily washed away. This results in ammonia being present in the mine water.

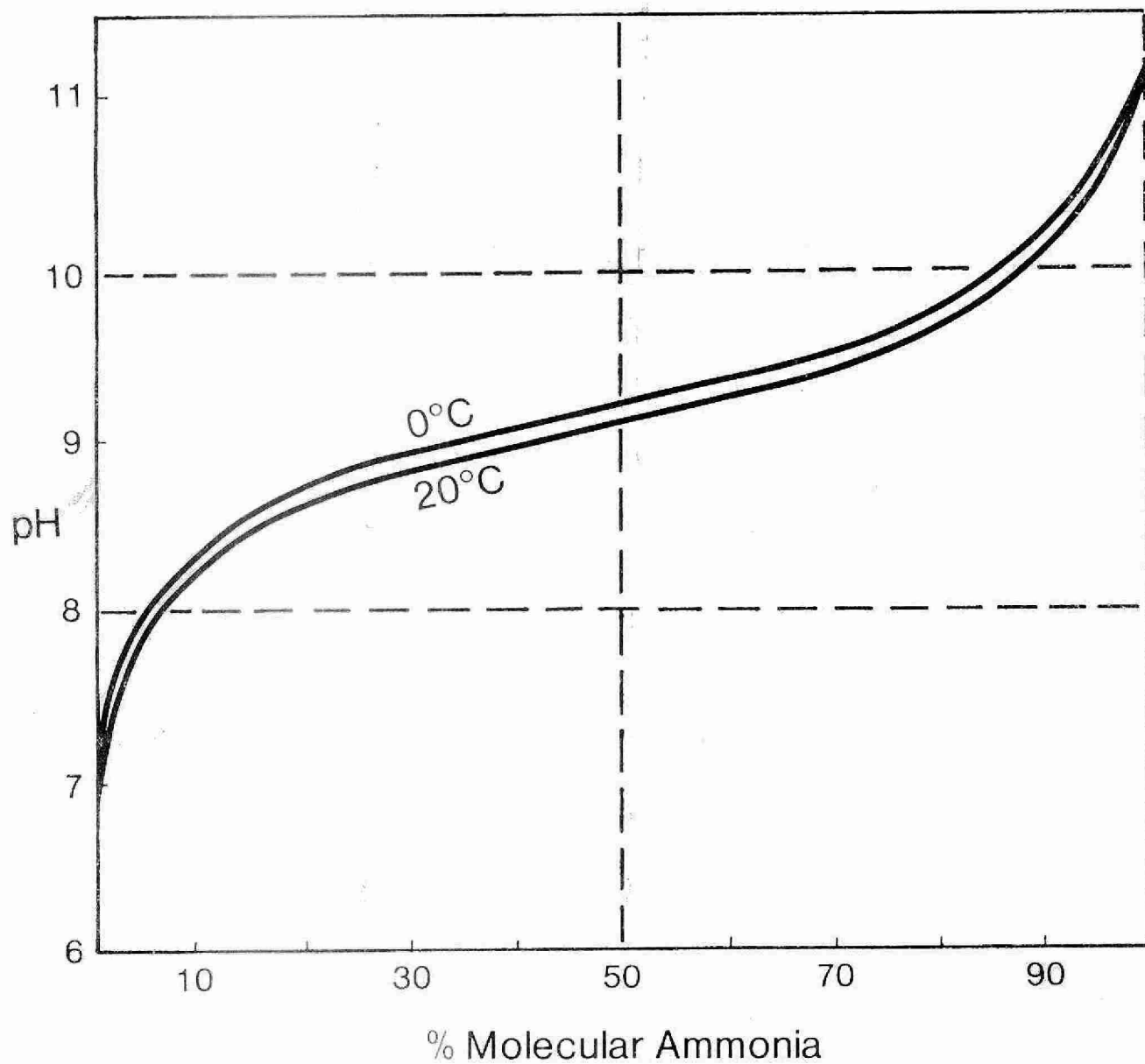


Figure 1

## THE EFFECT OF pH AND TEMPERATURE ON MOLECULAR AMMONIA

Other types of explosives are available which contain lower amounts of nitrogen compounds, however, it was agreed by all parties at the public hearings that current explosive selection should not be changed until a substitute offering an equal degree of miner safety and performance efficiency is found. To address the ammonia problem, the mining companies have initiated programmes to reduce the amount of explosive reaching mine water. The programmes include provisions to improve handling procedures, stronger packaging and miner education to promote better housekeeping underground. In its final report the Board concurred with these programmes.

Ammonia is also used during the processing of the ore. In the mill circuits at Elliot Lake, yellowcake is precipitated through ammonia addition. In conjunction with investigations of a number of milling modifications, the possible replacement of ammonia with magnesia, caustic and hydrogen peroxide were assed.

The mining companies preferred the use of magnesia as it had been used in previous operations. In the opinion of the Board, the environmental benefits of conversion to magnesia as a precipitating agent were enough to warrant recommendation of modifying all operating or planned mills.

### Nitrates

Nitrate is another nitrogen compound of concern in the Elliot Lake area. The recent trending towards higher concentrations in the lakes of the Serpent River Basin led to the request that the potential for reducing the amount of nitrates discharged to the environment be investigated.

Like ammonia, nitrates end up in the mine water through the use of ammonium nitrate based explosives. A programme to minimize the amounts of both of these nitrogenous compounds was previously described. The principal use of nitrates in

the milling circuit is as an eluting agent during the ion exchange process. To reduce or eliminate the discharge of nitrates from this source several milling modifications were examined. Some involved the use of other eluting agents while others replaced the ion exchange step with a solvent extraction process. Most of these milling modifications were shown to be capable of eliminating nitrates but would result in the discharge of other compounds which could include sodium, chloride, magnesium, isodecanol, kerosene or amines depending upon the modification.

Nitrate levels in the lakes of the Serpent River Basin generally tend to be higher with proximity to the discharges from the operating properties. Values typically range from less than 2 mg/L-N near the basin's discharge to 6 to 7 mg/L-N in the large lake immediately downstream of the operating properties.

Nitrates are not known to be toxic to fish except at very high levels. Levels of 45 to 70 mg/L-N have been measured in water supporting large chinook salmon with no apparent ill effects (Westin 1974). From these data and from other experiments dealing with nitrate toxicity, it has been estimated that concentrations of nitrate can be up to 25 to 35 mg/L-N for salmonids. Data describing the effects of sublethal concentrations of nitrates over prolonged periods of time are scarce.

The most stringent criterion for nitrates in water is Ontario's surface water supplies permissible level of 10 mg/L-N for nitrates plus nitrites (MOE 1975). Nitrite is formed either by the bacterial oxidation of ammonia or by the bacterial reduction of nitrate. The concentration of nitrites in natural water systems is typically very low.

Nitrates do not pose a toxicity hazard to adults but levels of more than 20 mg/L-N have been implicated in the disease

of methemoglobinemia during the first few weeks in the lives of infants. Infants have lower stomach acidity than adults permitting a microbial population to be present which reduces nitrates to nitrites. Exposure of the blood to nitrites results in the oxidation of hemoglobin to methemoglobin. This same phenomenon has also been observed in fish where nitrite levels were as low as 0.1 mg/L-N.

Conditions existing in the lakes of the Serpent River Basin, do not favour the accumulation of nitrites. At acidic pH values, the formation of nitrite by ammonia oxidation is slow. Any nitrite which is formed is rapidly oxidized to nitrate. None of the lakes have nitrate levels which exceed the 10 mg/L-N criterion and indeed none serve as surface water supplies with the exception of one lake which is used as the fresh water supply to one of the underground mines.

During the public hearings, the concern was voiced by the Ministry of the Environment that the discharges of nitrogen compounds could result in accelerating biological activity in the lakes of the basin. To assess this concern water quality experts from both Canada and the United States were asked to comment on the situation. Based upon general characteristics of lakes in the region and reinforced by local water quality data they felt that inherently low phosphorus levels preclude excessive biological activity. By hearing's end nitrate toxicity to fish, contamination of surface water supplies and acceleration of biological growth were shown as not being the problems originally envisaged. In the Board's opinion based on the evidence presented, "nitrates are not a present concern" in the Serpent River Sytem.

### Pyrites

Several of the concerns related to discharges to the aquatic environment stem from the presence of pyrites in the ores

mined at Elliot Lake. As a result, the mining companies were asked to investigate removal of pyrites in the milling of ores and to examine methods of ameliorating the detrimental influence pyrites can have in tailings containment areas.

Elliot Lake ores typically contain approximately 6 percent pyrites ( $\text{FeS}_2$ ). The content varies with ore grade and generally decreases as the ore grade decreases. As lower ore grades are recovered in the future, less pyritic material should be encountered.

Underground, bacterial oxidation of pyrites turns mine water acidic, subsequently permitting the dissolution of various heavy metals and radionuclides also present in the ore. In the mill, pyrites are collected with all of the other waste solids for transport to tailings containment basins. In a tailings area, pyrites provide the potential for sulphuric acid production by both chemical and bacterial oxidation. This can produce acidic seepages with high levels of dissolved metals and radionuclides. The presence of pyrites also requires neutralization of tailings prior to attempting to establish vegetation. Treatment alternatives deal primarily with providing isolation of pyrites from the environment.

Pyrite flotation in the mill circuit can be used to produce a pyrite concentrate for subsequent use in sulphuric acid production or separate containment. Complete pyrite removal is not technically feasible using the flotation method. Flotation could reduce pyrite discharge by 95 per cent but would also result in the presence of constituents such as sodium, potassium amyl xanthate and methyl isobutyl carbinol in tailings effluents. Approximately 5 per cent of the pyrite would not be removed and thus would still have the potential to generate acid.



Separate pyrite disposal would require monitoring and effluent treatment of additional disposal areas. Radium tends to associate with pyrite concentrate. It is therefore expected that any discharge from a separate pyrite containment area would have high acid and radium content. The value of separate pyrite containment is therefore reduced if such areas require long-term containment and discharge control.

The Board found that while the removal of most of the pyrite in the mill was possible, that reducing the influence of pyrite in tailings areas holds greater promise. As such, it recommended that further studies are needed, particularly in stabilizing pyrite in tailings, and in the handling and storage of pyritic concentrate.

To minimize the effects of pyrites in tailings areas, various waste management strategies have been put forward. These options include encapsulation, emplacement of physical covers, chemical fixation, inundation and vegetation. Based on present research and technology, vegetative stabilization appears to offer the most practical long-term approach for the reduction of pyrite oxidation. It is believed that vegetation greatly reduces acid generation by limiting the transport of oxygen into the tailings. Once abandoned areas have been flushed of process water and vegetated, effluent treatment should no longer be required.

#### Radium and Other Radionuclides

Throughout the public hearings, the behaviour of radionuclides and the nature of the radiological environment was repeatedly discussed. The testimonies of a number of experts were necessary to present both the understood facets of radioactivity and the debates surrounding many aspects. While the evidence touched upon many subjects, those discussed in detail included the potential for removal in the mill of radium and thorium, the interpretation of radium-226

analyses, and the effects of exposure to low levels of radiation.

The three radioactive decay series associated with uranium ore result in the presence of several isotopes of thorium and radium. Of the thorium isotopes, thorium-232 and thorium-230 are the longest-lived and most abundant. Through decay these produce radium-224 and radium-226 respectively. Radium-226 is the longest-lived of the radium isotopes and the radionuclide of greatest interest in the Elliot Lake area.

Approximately 99 per cent of the radium entering the mill, passes through the circuit to be discharged to a tailings area. Minute amounts report in the effluents from containment areas and are controlled through the addition of barium chloride and subsequent sedimentation.

Treatment of tailings area effluent with barium chloride offers a short-term method to control the release of radium. In the long-term a control method is not so readily apparent. Through vegetative stabilization and diversion of fresh water flows that pass through tailings areas it is projected that the release of radium would not pose any environmental or health related concerns. A research programme to assess the effectiveness of this approach is planned for the immediate future in the Elliot Lake area.

As an alternative to controlling radium in the external environment, the mining companies were asked to investigate the removal of radium in the mill. A process was used by Eldorado Nuclear Limited in the 1950's to extract radium from relatively small amounts of high grade ore. This technology was shown to be impractical (requiring more than 60 tonnes of chemicals to produce 1 gram of radium) and economically prohibitive for mines at Elliot Lake. Research by several organizations including the Canada Centre for

Mineral and Energy Technology may eventually produce a new process which both efficiently recovers uranium and concentrates radium (Ritcey 1977). As there is little market for radium, adequate methods would have to be developed for the long-term, safe storage of the concentrate. The Board concluded that radium removal in the mill was not practical based on present technology.

During the 1960's, thorium was extracted at one of the Elliot Lake operations, but decreasing world markets caused production to be halted. Extraction was through the use of several organics and recovered approximately 94 per cent of the dissolved thorium from barren solution. However, only approximately 60 per cent of the total amount of thorium reports in this stream.

There is at present no market for thorium, although one may exist within the next few decades. Since thorium was found to cause no appreciable environmental problems in a tailings basin, it appears to be a logical location to store the material. In its final report, the Board recommended that thorium removal in the mill not be required of the mining companies.

The effective removal of radium and thorium along with pyrites within the milling circuit, has not been demonstrated as a technical possibility but is still under investigation. It must also be stressed that if these contaminants are removed in the mill, they will require separate storage or disposal. Although several disposal options have been proposed, the long-term consequences of each option would require a separate assessment to assist in evaluating the overall desirability of the contaminant removal scheme.

Records of radium-226 analyses dating back to 1961 were discussed at length during the public hearings. The records

indicate that levels increased in many of the lakes of the Serpent River Basin, reaching maximum levels in the late 1960's. By 1978, values for most of the basin's lakes had declined to less than 10 pCi/L.

Much of the improvement is attributable to the treating of containment area decant streams with barium chloride which precipitates radium from solution. In attempting to assess these values, comparisons were made to the federal and provincial requirements.

The government agencies of many countries base standards related to radioactivity upon the work of the International Commission of Radiological Protection (ICRP). In Canada, both the federal standard and Ontario's guideline for radium-226 in water supplies are based upon ICRP recommendations published in the late 1950's. Applying their own factors of safety onto the ICRP value of 100 pCi/L for occupational exposure to radium-226 in drinking water, the federal standard was set at 10 pCi/L and the provincial guideline of 3 pCi/L developed. Throughout the public hearings, the meaning and consequences of these levels were debated. Witnesses expounded the virtues and conservatism of both levels in light of discharges from operating properties and their potential effects. In its final report, the Board expressed that hope that in time there be only one standard.

In addition to the radium guidelines and criteria, other aspects related to measuring radium levels in water were subject to contentious debate. Levels discussed thus far have referred to dissolved material, yet there is not agreement as to how samples to measure dissolved material are to be prepared. Filter sizes of 3, 1.2 and 0.45  $\mu\text{m}$  have been used without an understanding of the effect of filter size upon results. The lack of agreement as to what is meant by dissolved radium also led to discussions about the radioactivity associated with suspended material and speculation

as to the necessity of guidelines or criteria dealing with total radium levels. While suspended material is of little consequences in samples from lakes, recent measurements of the radioactivity associated with suspended material in mining property effluents has shown to be erratic and unpredictable.

While the utility of soluble versus total radium measurements remains to be evaluated, the Board recommended that radium standards eventually refer to levels of total radium.

During the hearings, it was brought to the attention of the Environmental Assessment Board that the ICRP was reassessing its previous recommendations. This summer the ICRP will publish new limits on oral intake of radium which, assuming a daily intake of 2 litres, is approximately 2600 pCi/L. This represents an increase of twenty-six times the present ICRP criterion. Imposing the same factors of safety used previously by federal and provincial agencies, the new levels for these agencies would become 260 and 78 pCi/L respectively. Adoption of these new levels is not anticipated but the work of the ICRP indicates a reassessment of current government positions is required. At present, a joint federal-provincial board is reviewing water standards and these new ICRP findings have been forwarded to it.

One of the most contested issues related to radioactivity is the effects of exposure to low levels of ionizing radiation. The issue, which has been debated at many forums lay, beyond the mandate of the Board but an effort was made by the participants to develop a basic understanding of the issues. Many pages of testimony dealt with issues such as the risks from inhaling various levels of radon, whether or not the use of the linear hypothesis for estimating risk is conservative, the risks from internally deposited radionuclides with particular emphasis on radium-226 and whether or not

there is a threshold below which there are no significant effects from radiation. As an illustration of discussions which arose during the hearings, estimates of the risk arising from drinking water with radium levels of 30 pCi/L varied by a factor of 800 000 in testimony presented at these hearings. And while the controversy continues, the majority of the evidence heard aligned itself with the latest findings of the ICRP in recommending that radium levels could be relaxed without significant detrimental effects. In fact it was explained by one expert that in a statistical sense the risk of developing a bone cancer from natural causes was approximately two-thousand times the risk of a bone cancer associated with drinking water containing radium at concentrations of 300 pCi/L as shown in Table 1.

Another important topic related to radioactivity that was discussed was the ALARA principle. This principle, which states that "all exposures should be kept as low as reasonably achieved, economic and social factors being taken into account", is recommended by the ICRP. In testimony, a majority of the experts felt that this principle should be interpreted as meaning that exposures be reduced only to the level where economic or social benefits become less than the costs associated with further reduction. It was also felt that the principle was applicable regardless of whatever standards for various radionuclides exist or are developed. The Board recommended that the ALARA principle should apply to all radionuclides released in the environment in the Elliot Lake area.

#### Waste Management Practices

Waste management programmes were discussed at length at the public hearings. Many aspects of water reuse, tailings containment basins, effluent treatment and tailings stabilization were examined. Two examples of the many topics

TABLE 1

RISK ESTIMATES FOR BONE SARCOMAS  
ASSOCIATED WITH RADION-226 IN DRINKING WATER

| <u>Level of Radium-226</u><br><u>In Drinking Water</u><br><u>(pCi/L)</u> | <u>Risk Estimates for</u><br><u>Bone Sarcomas from Radium-226</u><br><u>(50 year intake at 2 litres per day)</u> |
|--------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| 3                                                                        | $1.5 \times 10^{-11}$                                                                                            |
| 10                                                                       | $1.7 \times 10^{-10}$                                                                                            |
| 30                                                                       | $1.5 \times 10^{-9}$                                                                                             |
| 100                                                                      | $1.7 \times 10^{-8}$                                                                                             |
| 300                                                                      | $1.5 \times 10^{-7}$                                                                                             |

Risk estimate of a 20 year old developing a bone sarcoma during the next 50 years from natural causes is  $3.3 \times 10^{-4}$ .

Source: Roland 1979



addressed were assessment of the potential of backfilling underground and the reuse of mine water.

The placement of backfill underground can serve two distinct purposes. It can permit the recovery of ore retained in the pillars of previously mined areas or serve as a disposal technique for a portion of the tailings material that would otherwise require alternative surface containment. To date backfilling has only been used as a mining/recovery method.

Hydraulic backfilling has been successfully used in the Canadian metal mining industry for the past two decades. However, the only uranium mine that has practiced backfilling has been the Beaverlodge mine in Saskatchewan. In general, the successful use of backfilling is dictated by mining options and ground support methods. The relatively deeply sloping, rein-type of ore body and mining methods at Beaverlodge have allowed backfilling to be employed. Although large volumes of material have been placed underground at Beaverlodge, and some testing has been done at other locations, research into the techniques and effects of the use of uranium mill tailings is in its infancy.

A typical operation consists of cycloning tailings material to reduce the proportion of fines. This permits the high water percolation rates necessary for the material to consolidate after placement. One of the operating properties is proposing to introduce a pillar recovery research programme using hydraulic backfill in 1979. Provisions for drain lines, sumps and pumps, possible cement addition are planned.

The prospects of recovery of additional ores from pillars in previously mined areas make wide-scale dedication of areas to backfill economically imprudent. At operating mines existing stopes often serve as return air vents. The use of hydraulic backfill will still require the containment of the



finer fraction which comprise (approximately 50 percent of the total amount of material).

In its final report the Board recommended that both mining companies thoroughly reassess backfilling both an ore recovery technique and as a waste management option. They further recommended that both mining companies commence studies that examine economic operational and environmental aspects.

During the public hearings aspects related to the utilization of water underground were examined. In uranium mines the ore is repeatedly sprayed with water to minimize dust suppression. Water is also used for drinking water, washing rock faces, and cleaning equipment. This results in large volumes of water being used in the mine. In an attempt to find ways of reducing the fresh water at operating properties, this large demand was investigated.

After use in the mine, the water is directed to the mill where it is treated to recover dissolved uranium and remove heavy metals. The water is subsequently reused in other mill processes or discharged with the tailings. The quantity used underground can be directly related to the tons of ore broken per mining day since the major use of the water is for dust suppression. The amount varies from approximately 500 to 700 L/t (100 to 140 gal/ short ton). It is possible to reduce the quantity of water used underground but not without diminishing the degree of dust suppression. When the health and safety of the underground workers was taken into consideration such a reduction was discounted.

Alternatives for fresh water reduction that were then investigated included recirculation of treated mine water or the recycle of treated tailings effluent to the mine. Recirculation of treated mine water would not introduce a large reduction in fresh water demand unless it was possible

to also replace the mine water sent to the mill with tailings effluent. Similarly, if treated tailings effluent were used in the mine and subsequently used in the mill, the same reduction in fresh water consumption would result.

At the mines in Elliot Lake, the existing underground water system has potable water available from any main. To recycle water underground would necessitate that dissolved and/or particulate uranium, radium, ammonia, nitrate, silica, heavy metals and sulphates meet potable water standards and criteria. The choice of treatment process is dependent upon the number and concentrations of contaminants to be removed. Even with incorporation of these treatment processes, all toxicants may not be removed. The safety of underground workers was again a leading consideration in reviewing the viability of such a system. A breakdown in the treatment equipment or periodic malfunctions in its operation could potentially expose workers to an unsafe water supply.

Both mine water and tailings effluent contain silica, due to the high silica content of the ore body. Since most underground water is used for dust suppression, recycling may increase levels of airborne silica. More information is needed to evaluate this potential and the effects. A further problem that may result from the use of treated effluent for dust suppression underground is the possibility of increased calcium deposition or scaling in the drills and sprays thereby hindering proper wetting-down practices in the mines.

### Conclusion

During the course of the hearings a number of environmental concerns were discussed at length. Coincident with discussions of the concerns were examined numerous alternatives and strategies that were forwarded with the intent of mini-

mizing the environmental effects of mining in the area. In assessing the consequences and risks associated with various existing conditions and proposed modifications, the hearings acted as a forum at which information from many sources was presented. Through the examination of concerns from several perspectives, new appreciations of both specific and general features of environmental assessment, restoration and protection were developed. The Board concluded that the technology exists to carry out the expansion of the uranium mines at Elliot Lake in an environmental acceptable manner in the short-term and that studies be initiated and/or continued in pursuit of solutions to the long-term aspects of waste management.

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## SESSION II

### CHAIRMAN



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#### **Water Management in Ontario**

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#### **Biological Studies of the St. Clair River**

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#### **Use of Low-Grade Heat for Electrical Generating Stations**

Dr. W. R. Effer, Manager, Environmental  
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A. G. Barnstaple  
Supervising Design Engineer  
Process Development  
Power Equipment & Engineering Studies  
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#### **The Design and Commissioning of the Wastewater Treating System at Texaco's Nanticoke Refinery**

R. D. Cameron  
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# WATER MANAGEMENT

## IN ONTARIO

by

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### INTRODUCTION

In the summer of 1976, the Ontario Ministry of the Environment initiated a review and revision of the 1970 publication "Guidelines and Criteria for Water Quality Management in Ontario". The project also involved expanding the publication to include ground water and surface water quantity management.

The project was undertaken through a Guidelines and Criteria Review Committee, which oversaw the entire project. The Committee was composed of provincial government representatives of the Environment, Natural Resources, and Health ministries. Four Working Groups reporting to the Review Committee were responsible for reviewing and revising the existing water quality criteria and the guidelines for surface and ground water quality and quantity management. They also reviewed the implications of the proposed revisions on existing water oriented guidelines, policies, criteria and objectives.

The publication entitled "WATER MANAGEMENT - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment", fully documents the end product of the project and is summarized in this paper. It should be noted that this publication outlines the water management approach of the Ministry of the Environment only. Other water management aspects such as flooding, for example, are under the jurisdiction of other federal or provincial agencies.

The proposal went through a review by staff of the Ministry of the Environment and was also circulated for comment to Ontario Government agencies which would be affected by the revised water management approach.

## SURFACE WATER QUALITY MANAGEMENT

### Revision of Existing Guidelines

This aspect of the project began with an examination of the difficulties encountered with the implementation of the original guidelines. This involved seeking and evaluating the comments of regional and head office staff in the Ministry of the Environment.

It was concluded that the previous surface-water quality guidelines had a number of serious limitations:

- they were written in too brief, vague and general terms;
- they lacked any clear outline of how they should be implemented;
- they lacked an evaluation of economic considerations;
- by requiring improvement of poor water quality and allowing some degradation of high quality water, they provided no effective mechanism for maintaining high quality water.

Several of the original guidelines had not been implemented. For example, no water quality standards had been established for specific drainage basins; no mechanism had been established for maintenance of high quality water; effluent requirements based on basin standards had not been established and reserve capacity had been set aside only in rare cases.

As a result, water resource managers were frequently forced to make decisions on such issues as what uses should be protected, or where the criteria should be enforced or relaxed, with no clear policy or guidelines to follow and often with insufficient data or resources.

The committee established to revise the document agreed that a general statement of goal and policies, accompanied by fairly detailed implementation procedures, should be developed to replace the existing guidelines.

In addition to the above, several other factors influenced the development of the new guidelines:

1. the views of the International Joint Commission (IJC) as set out in its proposed general and specific objectives for water quality;
2. the undertaking by the province, in the Canada-Ontario Accord, to establish and enforce effluent requirements at least as stringent as the agreed national baseline requirements;
3. the unofficial views of U.S. agencies that Ontario should implement water quality standards or some other approach with more force than guidelines and criteria;
4. attempts to avoid the need for legislative amendments;



5. attempts to minimize any need for staff or funding increases.

Proceeding from this base, and following preparation of a number of working papers on several water management concepts and much discussion, the following conclusions were reached.

An ideal water quality management program would have the following components:

- determination of what water uses should be protected in every water body;
- establishment of ambient water quality criteria to protect each use;
- calculation of maximum allowable waste loadings on a case-by-case basis for all existing and proposed discharges.

This represents an ideal water quality management approach, and if the cost of achieving specified effluent quality could then be estimated and weighed against the water uses that are protected, it could be seen as a form of benefit-cost analysis. However, there is a wide variety of water uses, each with its own water-quality requirements. The variety of possible uses, as well as the issue of how to determine what use(s) to protect in a given area, further complicate the picture. In addition, current knowledge is limited on some aspects of safe levels of quality for some parameters and uses.

For these reasons, the theoretically ideal management approach was considered too complex, time-consuming and expensive to implement on all water bodies of the province.

The province's main concerns are the protection of public health and the protection of fish and aquatic life. Accordingly, a single goal was established as the target for all surface waters in the province:

#### Goal

TO ENSURE THAT THE SURFACE WATERS OF THE PROVINCE ARE OF A QUALITY WHICH IS SATISFACTORY FOR AQUATIC LIFE AND RECREATION.

The Provincial Water Quality Objectives represent the level of quality for many parameters which will ensure that the water quality is suitable for aquatic life and recreation. In general, water meeting this quality will be suitable for most other beneficial uses, including raw water supply for human consumption and agricultural use. A major advantage of this approach is that it clearly establishes the uses to be protected. For the few exceptions in those locations where better water quality is required to protect other beneficial uses, the appropriate water quality objectives will be applied.

## Objectives

The Provincial Water Quality Objectives represent the revisions to the existing criteria and are based mainly on a review of the recommendations of the International Joint Commission and of the U.S. Environmental Protection Agency. The rationale for each Objective is contained in a separate report by the Ministry of the Environment.

Serious consideration was given to the idea of promulgating legal, province-wide or individual river basin standards of water quality. (In this context, standards are defined as legally prescribed limits of water quality established under statutory authority). It was concluded that the use of standards is not recommended, mainly because:

- enforcement of receiving water standards can be extremely difficult because of the problems in proving what source(s) caused the violation and because monitoring receiving water quality for enforcement purposes would require funding and manpower well beyond the resources available to the Ministry;
- water quality would tend to be degraded to the minimum permissible levels as waste dischargers seek to get by with the least possible treatment;
- development of different standards for individual basins requires detailed and costly surveys.

## Policies

Following the goal statement are five statements of policy on surface-water quality management:

### 1. Areas with Water Quality Better than the Objectives

IN AREAS WHICH HAVE QUALITY BETTER THAN THE PROVINCIAL WATER QUALITY OBJECTIVES, WATER QUALITY SHALL BE MAINTAINED AT OR ABOVE THE OBJECTIVES.

### 2. Areas with Water Quality Not Meeting the Objectives

WATER QUALITY WHICH PRESENTLY DOES NOT MEET THE PROVINCIAL WATER QUALITY OBJECTIVES SHALL NOT BE DEGRADED FURTHER AND ALL PRACTICAL MEASURES SHALL BE TAKEN TO UPGRADE THE WATER QUALITY TO THE OBJECTIVES.

### 3. Effluent Requirements

EFFLUENT REQUIREMENTS WILL BE ESTABLISHED ON A CASE-BY-CASE BASIS. IN ESTABLISHING EFFLUENT REQUIREMENTS, THE CHARACTERISTICS OF THE RECEIVING WATER BODY WILL BE CONSIDERED, AS WILL FEDERAL AND PROVINCIAL EFFLUENT REGULATIONS AND GUIDELINES WHERE APPLICABLE. THE EFFLUENT REQUIREMENTS SO DERIVED WILL BE INCORPORATED INTO CERTIFICATES OF APPROVAL (UNDER SECTION 42, ONTARIO WATER RESOURCES

ACT) AND WILL SPECIFY BOTH WASTE LOADINGS AND CONCENTRATIONS.

In implementing Policy 3, the acceptable loadings or concentrations will be based on the most stringent of receiving water assessments and federal or provincial effluent regulations or guidelines.

Many considerations must be taken into account when establishing effluent requirements. The more important ones dealt with in the implementation procedures include discussions of non-point sources, the types of receiving water assessment techniques to be used, toxicity testing, and how the Federal effluent regulations and guidelines are to be applied. A detailed procedures on how to deal with the taking and discharge of cooling water is also provided.

Policy 3 represents an essential aspect of the proposed surface-water quality management approach, as it provides the basis for the systematic establishment of effluent requirements. The lack of such an approach was identified as a problem with the original guidelines. Moreover, the decision not to recommend receiving water or province-wide effluent standards was predicated in part on the basis that effluent requirements would be established as a legal requirement on a case-by-case basis.

#### 4. Hazardous Substances

Special preventive measures are required to deal with the release of hazardous or potentially hazardous substances. Accordingly, the Ministry's policy is to:

- i) PREVENT THE RELEASE OF SUBSTANCES WITH ZERO TOLERANCE LIMITS (DDT, MERCURY, DECHLORANE (MIREX), PCB, PBB)
- ii) ENSURE THAT SPECIAL MEASURES ARE TAKEN ON A CASE-BY-CASE BASIS TO MINIMIZE THE RELEASE OF ANY POTENTIALLY HAZARDOUS SUBSTANCES FOR WHICH PROVINCIAL WATER QUALITY OBJECTIVES HAVE NOT YET BEEN ESTABLISHED.

Policy 4 requires the elimination of a short list of substances from all controllable sources and requires that care be taken in the release of a second list of substances of unknown but potential hazard.

The Ministry's approach to hazardous substances emphasizes preventive measures in dealing with the release of both known and potentially hazardous substances. This approach reflects the fact that inadequate knowledge exists about the degree of safety or hazard for many substances. These substances are included in the Water Quality Objective listing where adequate scientific data exist for establishing water quality criteria. Discharge controls are based on the waste assimilative capacity or federal and provincial effluent requirements as discussed in the previous section entitled "Effluent Requirements". The other substances with less reliable scientific data were grouped into two categories, namely, substances

with zero tolerance limits, and substances with undefined tolerance limits. The zero tolerance limits refers to the fact that these substances can bio-accumulate or concentrate in the aquatic environment to the extent that they are harmful or lethal to organisms. Consequently, any release of these substances should be eliminated. The intent here is to prohibit all new discharges and reduce all existing releases to the lowest practical limit.

Those substances with undefined tolerance limits lack the scientific data to develop water quality objectives, yet indications are that they may be harmful to health or the environment. Accordingly, caution is recommended and the release of such substances should be evaluated on a case-by-case basis. The substances falling into these two categories are tabulated in the publication.

#### 5. Mixing Zones

A MIXING ZONE IS DEFINED AS AN AREA OF WATER CONTIGUOUS TO A POINT SOURCE WHERE THE WATER QUALITY DOES NOT COMPLY WITH THE PROVINCIAL WATER QUALITY OBJECTIVES. TERMS AND CONDITIONS RELATED TO A MIXING ZONE WILL BE DESIGNATED ON A CASE-BY-CASE BASIS AND MAY BE SPECIFIED IN CERTIFICATES OF APPROVAL, CONTROL ORDERS, REQUIREMENT AND DIRECTIONS, OR APPROVALS TO PROCEED UNDER THE ENVIRONMENTAL ASSESSMENT ACT. THE SIZE OF THE MIXING ZONE SHALL BE MINIMIZED TO THE GREATEST POSSIBLE DEGREE AND UNDER NO CIRCUMSTANCES IS THE MIXING ZONE TO BE USED AS AN ALTERNATIVE TO TREATMENT.

There was also considerable discussion on whether to retain the arbitrary requirement from the previous set of guidelines that a mixing zone should not exceed 1/3 of the stream width. This has been changed to a more general statement that a mixing zone shall not be allowed to prevent the passage of fish and aquatic life.

#### Deviation from Policy 2

It is recognized that in exceptional cases, it may not be possible to strictly apply Policy 2 (no further degradation and upgrading where possible). Accordingly, if it can be shown that all reasonable and practical measures to achieve the Objectives have been taken, and that:

1. the Provincial Water Quality Objectives are not attainable because of natural background water quality, or
2. the Provincial Water Quality Objectives are not attainable because of irreversible man-induced conditions, or
3. to attain or maintain the Provincial Water Quality Objectives would result in substantial and widespread adverse economic and social impact, or
4. suitable treatment techniques are not available,

then water quality degradation may be allowed with the approval of

the Director, Water Resources Branch and the appropriate Regional Director. Also, public hearings would likely be required under provincial legislation before such degradation would be permitted. The intent is to closely monitor deviations of this type with the purpose of reversing such degradation as soon as new treatment technology or economic conditions permit.

### SURFACE WATER QUANTITY MANAGEMENT

The protection and control of surface water quantity is another key component of Ontario's surface-water management strategy for two reasons. Firstly, control of water quantity is needed in some areas to avoid conflicts among various users. Secondly, water quantity and quality management are closely related, inasmuch as the amount and physical characteristics of water available is an important aspect of water quality. Surface water quantity management in Ontario involves a combination of common law, land patent, and federal and provincial statutes, and has the following goal:

#### Goal

TO ENSURE A FAIR SHARING OF THE AVAILABLE SUPPLY OF WATER TO PROTECT BOTH WITHDRAWAL AND IN-PLACE USES OF WATER.

#### Policies

##### Water Quality-Quantity Inter-relationship

THE WITHDRAWAL OF WATER FROM AND DISCHARGE OF WATER TO SURFACE WATER BODIES WILL BE CONTROLLED TO ASSIST IN MAINTAINING OR RESTORING WATER QUALITY FOR THE PROTECTION OF AQUATIC LIFE AND RECREATION.

This policy statement is complemented by the fact that the surface-water quantity management program is to ensure that a sufficient supply of water is maintained to provide an adequate quantity of water for downstream uses. In addition, controls on land-use practices, discharges of water from urban drainage, agricultural drainage and similar artificial discharges will be encouraged to prevent water quality degradation and to minimize any increase in peak flows.

##### Permits to Take Water

SURFACE WATER TAKINGS WILL BE CONTROLLED TO PREVENT INTERFERENCE WITH OTHER USES OF WATER WHEREVER POSSIBLE AND TO RESOLVE SUCH PROBLEMS IF THEY DO OCCUR.

Under Section 37 of the Ontario Water Resources Act, the Ministry of the Environment administers a water permit program, under which most takings in excess of 10,000 gallons in a day require authorization by means of a Permit to Take Water. While the water permit legislation is designed to manage the use of water resources in the Province, it does not supersede the common-law

riparian rights to the use of water, but is an added control. Thus, while riparian rights are not superseded, they may be limited in some cases by the water-permit legislation. Other takings which are generally exempt from the water-permit legislation, but which are found to interfere seriously with other users, can be prohibited without a permit and thus brought under the provisions of a water permit. The only exception to this provision is the taking of water by an individual for ordinary household purposes, livestock watering, and firefighting.

When evaluating the relative priority of uses in an area, the taking of water for private, domestic, and farm purposes is considered the most important use, generally followed by municipal water supply. The use of water for pollution control, flood control, fire protection, recreation, and wildlife preservation are also important considerations. The taking of water for industrial, commercial and irrigation purposes is regulated by the availability of the supply, the efficiency of use, and established uses in an area.

If streamflow interference results from simultaneous takings by several takers (e.g. for irrigation), attempts may be made to arrange for the takers to agree to a schedule of taking on alternate days or at different times of the day. Alternatively, all takers from the stream may be required to reduce their taking to a lower rate.

When water is taken from streams which cease to flow seasonally due to natural causes, downstream flow must be maintained whenever there is an inflow.

#### Surface Water Conservation

ALL REASONABLE AND PRACTICAL MEASURES SHOULD BE TAKEN TO CONSERVE THE QUANTITY OF SURFACE WATER, TO MAXIMIZE ITS AVAILABILITY FOR EXISTING OR POTENTIAL BENEFICIAL USES.

A majority of surface-water quantity interference problems in the province involve a stoppage or serious reduction in flow caused by the storage of water by damming and the taking of water for irrigation. Some problems caused by direct takings are resolved by a reduction in the rate of takings. If the problem becomes recurrent, it may be necessary to require that off-stream storage works be constructed so that peak requirements can be met.

In areas where a significant proportion of streamflow depends on ground-water discharge from flowing wells, special management practices will be undertaken to conserve ground water and thereby protect streamflows.

Large scale ground-water development close to streams will be allowed only after due regard to the maintenance of sufficient streamflow to protect downstream uses.



## GROUND WATER QUALITY MANAGEMENT

### Background

The Ministry has not previously published any goal or policy statements related to ground-water quality management. This situation was responsible, in part, for some of the problems the Ministry encountered in dealing with ground-water quality situations.

The ground water quality management approach spells out the basic Ministry policies and places the onus on the proponent to prepare a proposal he feels will meet these policies. An elaborate review approach, including extensive monitoring and contingency plan requirements, would apply only to proposed facilities in those environments most sensitive to contamination, where failure of the facility would have serious environmental consequences.

Restoration of ground-water quality is both extremely difficult and expensive. Locating the source of contamination can at times be difficult, and with present control technologies, ground water contamination can be considered to be long-term once it occurs. For these reasons, the preventive aspects of ground-water quality management are stressed.

### Goal

TO PROTECT THE QUALITY OF GROUND WATER FOR THE GREATEST NUMBER OF BENEFICIAL USES.

In the majority of cases, human consumption will be the most important use of water to be protected, but there are other ground-water uses with specific water quality requirements which will also be protected. Tables of water quality criteria for drinking water and agriculture, the commonest ground-water uses in Ontario, are included in the publication. In addition, protection of aquatic life is a consideration in cases where ground water is a significant component of streamflow.

### Policies

#### 1. Regulated\* Sources of Contamination

THE WASTE CONTROL REQUIREMENTS FOR PROPOSED REGULATED WASTE DISCHARGES WILL BE ESTABLISHED ON A CASE-BY-CASE BASIS. AS A GENERAL POLICY, WATER QUALITY DEGRADATION WILL BE CONTROLLED IN ORDER TO PROTECT REASONABLE USES, EXISTING OR PROPOSED, OF BOTH GROUND AND SURFACE WATERS. THE MINISTRY REQUIREMENTS RELATING TO THE QUANTITY AND THE QUALITY OF THE DISCHARGE WILL BE SPECIFIED AND CONTROL MEASURES MAY ALSO BE STIPULATED IN CERTIFICATES OF APPROVAL. THE TREATMENT OR ELIMINATION OF POLLUTANTS FROM EXISTING

\* Regulated and unregulated refer to whether or not an activity requires specific approval under the Ontario Water Resources Act or the Environmental Protection Act.

ACTIVITIES WILL BE REQUIRED WHERE IT IS DEMONSTRATED THAT SUCH MEASURES ARE PRACTICABLE AND NECESSARY TO CORRECT USE IMPAIRMENT AND WILL PREVENT FURTHER DEGRADATION OR IMPROVE WATER QUALITY. WHERE SUCH MEASURES ARE NOT PRACTICABLE, THE MINISTRY MAY REQUIRE REPLACEMENT OF THE AFFECTED SUPPLIES.

The concept of protecting potential as well as existing uses is important. It is general practice to allow individuals to contaminate ground water quality beneath their own property. However, there may be cases where a person may purchase all or most of the land overlying an aquifer for use as a waste disposal site. Where such a water resource represents, for example, an important future source of domestic water supply, it would be prudent to protect the source and arrange for another site to be chosen for waste attenuation.

The concept of reasonable use is an important consideration. This is designed to resolve situations where a nearby property owner alleges that he plans a future use of ground-water with very high quality requirement, when the sole purpose is to prevent development of a waste-disposal site.

Policy 1 will apply both to proposed sites and to existing, regulated activities which were not subject to control measures at their inception, but which now have an effect not anticipated at the time they were approved.

Policy 1 also states that the Ministry may stipulate in the Certificate of Approval control measures related to the facility. The onus for necessary control measures is on the proponent, and thus does not have to be so specified. As it might be desirable to do so in some instances, it is included as an optional consideration.

## 2. Unregulated\* Sources of Contamination

ALL REASONABLE MEASURES SHALL BE UNDERTAKEN TO REDUCE OR PREVENT THE CONTAMINATION OF GROUND WATER BY PROPOSED OR EXISTING UNREGULATED ACTIVITIES.

Policy 2 is, of necessity, a much weaker statement, as it applies to situations which do not require the specific approval of the Ministry. Once the results of studies such as Pollution from Land Use Activities Reference Group (PLUARG) become available, this policy can be improved during the continuing review and update of policies that has been provided for. However, it must be recognized that practical solutions to many problems caused by activities related to this policy will not be found in the near future.

## GROUND WATER QUANTITY MANAGEMENT

As with its surface-water counterpart, the ground-water quantity management proposal is based on well-established policies and procedures which have been approved as part of the water-taking permit program.



## Goal

TO ENSURE THE FAIR SHARING AND CONSERVATION OF GROUND WATER.

This goal statement is backed up by the following policies.

## Policies

Generally, the Permit to Take Water program applies equally to surface and ground water quantity management in Ontario, and reference should be made to the earlier section dealing with surface water. However, the policies dealing with Resolution of Interference Problems and Ground Water Conservation are sufficiently different to be dealt with in more detail here.

### Resolution of Interference Problems

IN THE EVENT THAT A GROUND WATER TAKING AUTHORIZED BY PERMIT INTERFERES WITH ANOTHER WATER SUPPLY OBTAINED FROM ANY ADEQUATE SOURCE THAT WAS IN USE PRIOR TO THE ISSUANCE OF THE PERMIT, THE PARTY CAUSING THE INTERFERENCE SHALL RESTORE THE AFFECTED SUPPLY OR REDUCE THE TAKING TO ELIMINATE THE INTERFERENCE.

There are several important factors that influence the implementation of this policy on a case-by-case basis. For example, the free flow from a flowing well is not protected. However, restoration is required of a previously adequate supply from a well which flowed prior to interference. Restoration of supplies is required if ground-water takings cause streamflow interference. Well-water supplies do not have to be restored if the interference was caused by works for the community and if community water service is available. In short term interference problems, a temporary supply should be made available.

### Ground Water Conservation

ALL REASONABLE AND PRACTICAL MEASURES SHALL BE TAKEN TO PROMOTE THE CONSERVATION OF GROUND WATER.

In order to implement this policy, measures such as metering of withdrawals, installation of observation wells and monitoring of pumping and non-pumping levels are required, while artificial recharge is encouraged. In areas where streamflow largely depends on ground water, special management practices should be implemented to conserve ground water. Protection of areas with high infiltration rates is good practice in most cases.

### IMPLEMENTATION PHASE

A vital aspect of the project is ensuring the effective implementation of the revised program. The main thrust involves the development of detailed implementation procedures to assist Ministry staff on issues which to date have not been effectively dealt with or where an updated approach is warranted. To this end, an

Implementation Committee has been formed to oversee the activity of five Working Groups charged with developing the necessary implementation procedures. The importance placed on the implementation phase is reflected in the fact that the Committee is chaired by an Assistant Deputy Minister. The Working Groups are currently undertaking a variety of duties which include;

- the establishment of a mechanism for the continuous review and periodic updating of the Water Quality Objectives and lists of hazardous substances;
- the development of procedures manuals on a variety of water-quality assessment issues such as: determining compliance with the Objectives, non-point source management, assessment of the impact of proposed discharges, designation of mixing zones, and establishment of effluent requirements;
- the further development of implementation procedures concerning ground-water quality management.

It is hoped that this approach will permit the Ministry to implement the revised water management program in the most effective fashion.

Biological Studies of the St. Clair River  
by  
S. Thornley, Southwestern Region  
Ministry of the Environment  
London, Ontario

Two major biological surveys of the St. Clair River have been conducted by the Ontario Government. The first was conducted in 1968 by the then Ontario Water Resources Commission. The second was conducted in 1977 by the Ontario Ministry of the Environment. The 1977 survey was an integral part of the broader St. Clair River Organics Study designed to investigate the presence and significance of organic compounds in the water, sediment and biota of the St. Clair River. The 1977 survey was also designed to afford a comparison with the results of the 1968 survey.

The St. Clair River flows from Lake Huron in the north to Lake St. Clair in the south, a distance of about 64 kilometres. It is the fifth largest river in Canada on the basis of flow volume (approximately 5500 m<sup>3</sup>/sec.) and averages about 0.8 kilometres (½ mile) in width (Figure 1).

The Great Lakes - St. Lawrence system is the fastest growing trade route in the world. The St. Clair River - Lake St. Clair - Detroit River is the busiest section of this system. More than 100 million tons pass through this route each year. This is more than the combined tonnage recorded for the Panama, Kiel and Suez Canals. Ships pass up or down the St. Clair River at a rate of one every seven minutes.

Because the St. Clair River is a navigable waterway used heavily by commercial shipping traffic it is dredged regularly to maintain a shipping channel. Approximately ninety percent of the flow travels down this main channel at high velocities. The remaining waters travel at slower velocities along either shoreline. The river therefore essentially flows as three separate rivers since the near-shore waters along either the American or Canadian shores do not effectively mix with or cross the main channel waters because of the flow differential. So, despite having the fifth largest flow volume, only about five percent of the

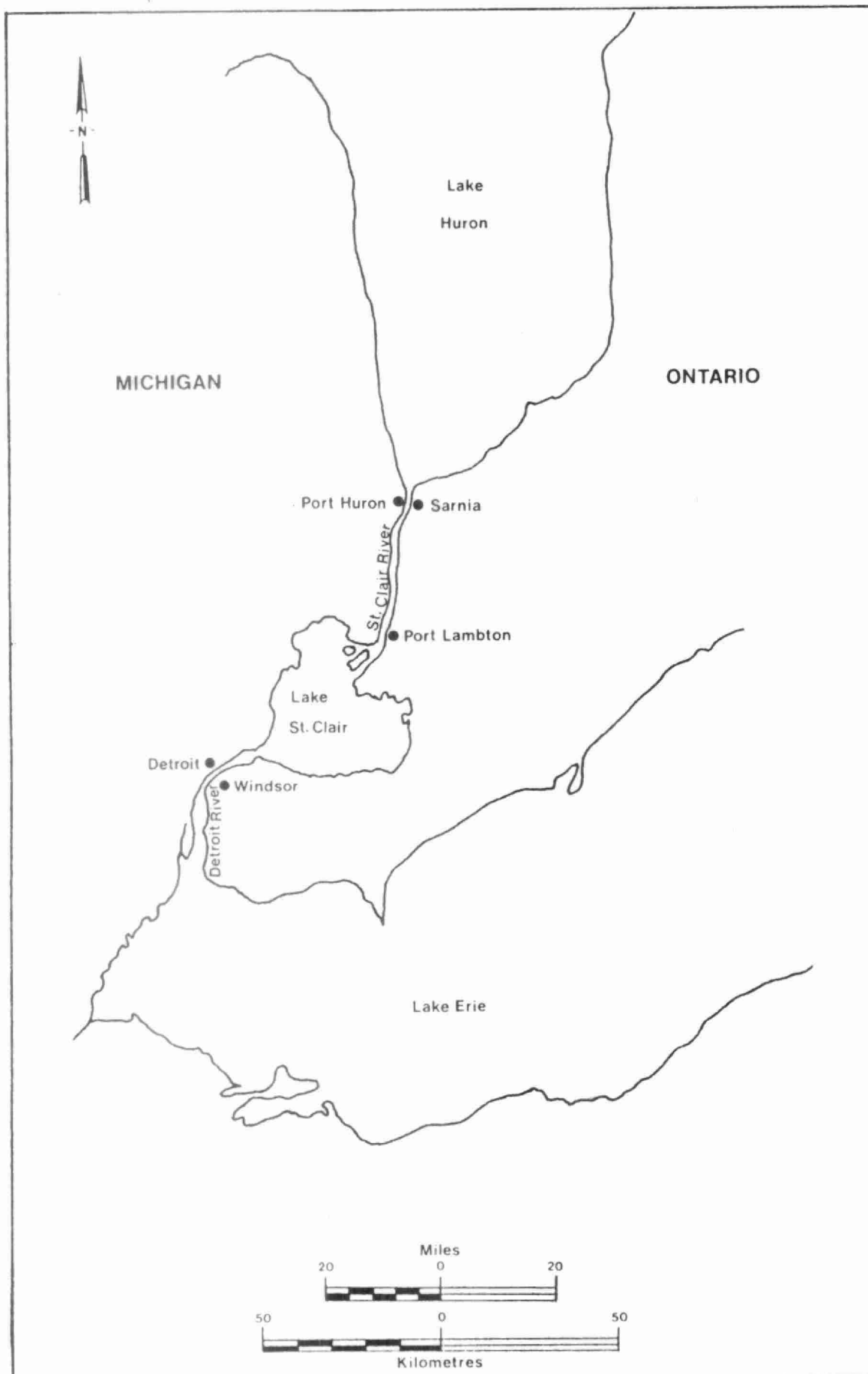


Figure 1. Location Map.

total flow is available for dilution along either shoreline. This is a very important characteristic of the river in so much as it allowed for a comparison of the impacts from the heavily industrialized Canadian shoreline on the river biology with the impacts from the primarily residential and resort development along the American shoreline.

The main thrust of the two biological surveys was the collection of bottom-dwelling macroinvertebrates. Commonly known macroinvertebrates include such organisms as leech, snails, clams, crayfish and perhaps mayfly larvae because of their recent prominence in the improvement of Lake Erie water quality. Macroinvertebrate organisms were collected on three occasions; August, 1968; May-June, 1977 and July-August, 1977 from sixty nine locations using a Ponar dredge (Figure 2). From three to five samples were analysed at each station.

Macroinvertebrates are of particular interest to the aquatic biologist because:

1. They are very sensitive to even the most subtle changes in water quality.
2. They are relatively immobile and reflect conditions from where they are collected.
3. They have extended life cycles in water (typically several months) and therefore reflect conditions over this extended period.
4. They are relatively small and are found in large numbers which facilitates both collection and analysis.

A total of 94 different types (taxa) of macroinvertebrates were collected from the St. Clair River in 1977. These data were analysed using two methods.

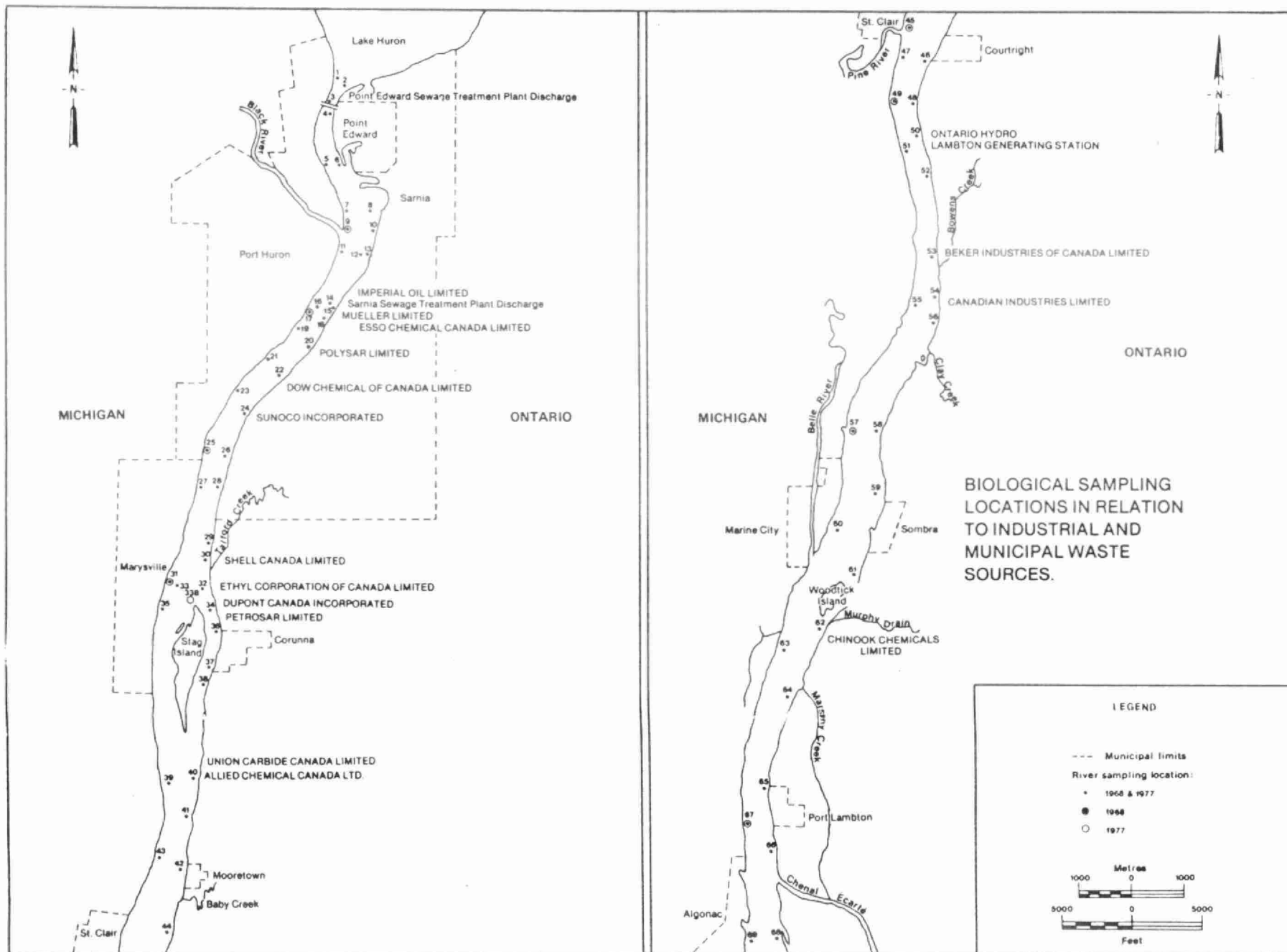


Figure 2. Biological sampling locations in relation to industrial and municipal waste sources.

The first method looked at numbers of organisms and variety of taxa from station to station. The stations were grouped according to the section of the river in which they were located. Section A contained stations 1-16, located upstream from the major industrial complex and included approximately 6 kilometres of river. Section B contained stations 17-40 located in that portion of river containing the major complex of Canadian industries (approximately 13 kilometres of river). Section C contained stations 41-53 located downstream from the concentration of Canadian industry (approximately 12 kilometres of river). Section D containing stations 54-69 constituted the furthest downstream reach of our sampling area and covered approximately 17 kilometres of river.

The results of this method of analysis are presented in figures 3, 4 and 5. The consistency in the numbers and particularly the variety of organisms is evident along the American side of the river and along the Canadian shoreline of Section A. In contrast, a disrupted benthos is evident along extensive portions of the remaining Canadian shoreline. In particular Section B demonstrated serious impairment of the benthos. On all three sampling dates no intolerant organisms were present in Section B. In the 1968 documentation intolerant organisms had not re-established themselves along the Canadian shore of the entire sampling area. Although still seriously polluted in 1977, the two samplings showed that by comparison, conditions had improved since 1968. A greater number and variety of organisms was documented in Section B and intolerant taxa had re-established themselves in Section D during 1977.

The second method of analysis looked at the macro-invertebrate data on a community level of interpretation. Such an analysis was accomplished through a number of statistical

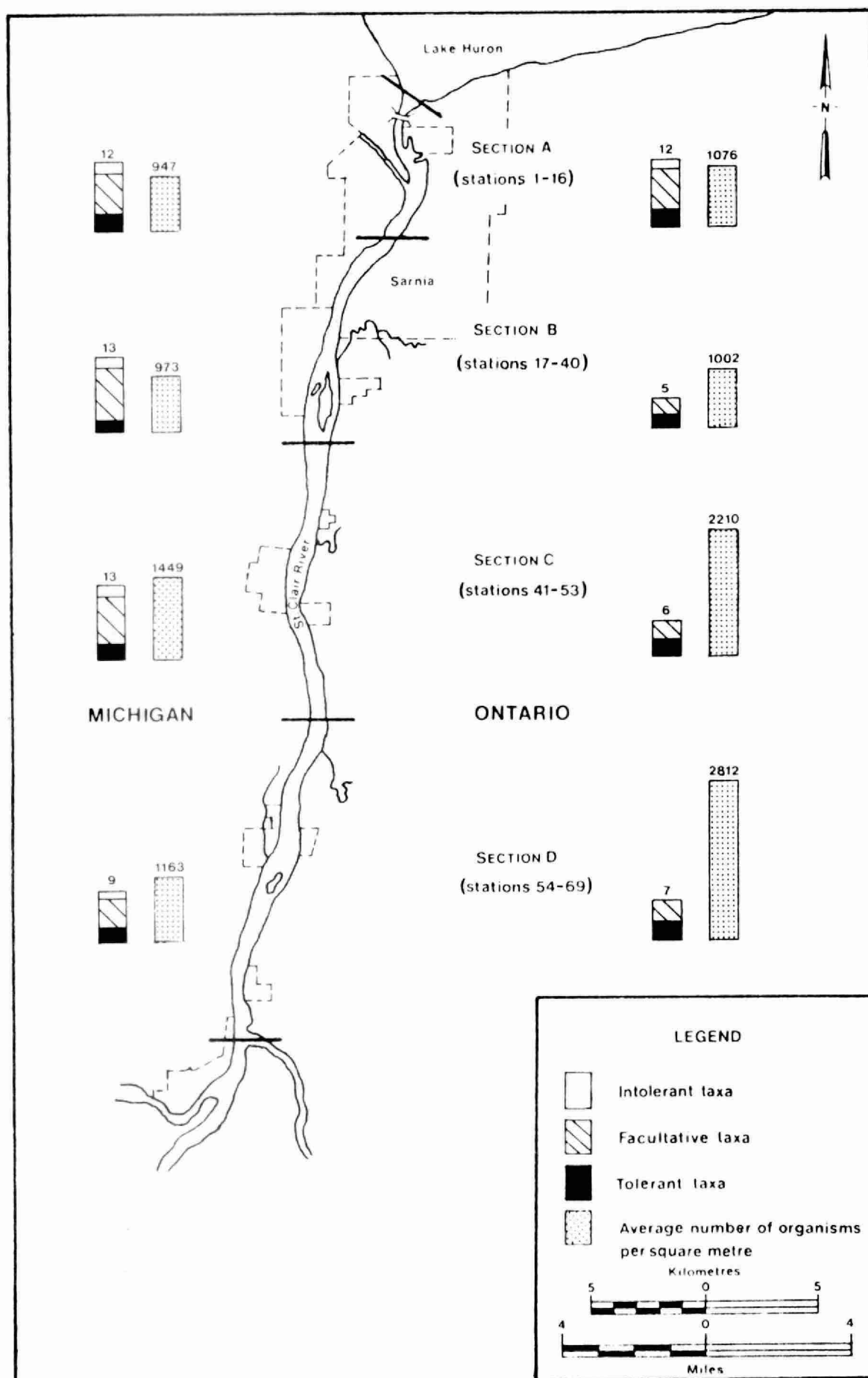


Figure 3. Average number of taxa per station and organisms per  $m^2$  in four major sections of the St. Clair River, August, 1968.



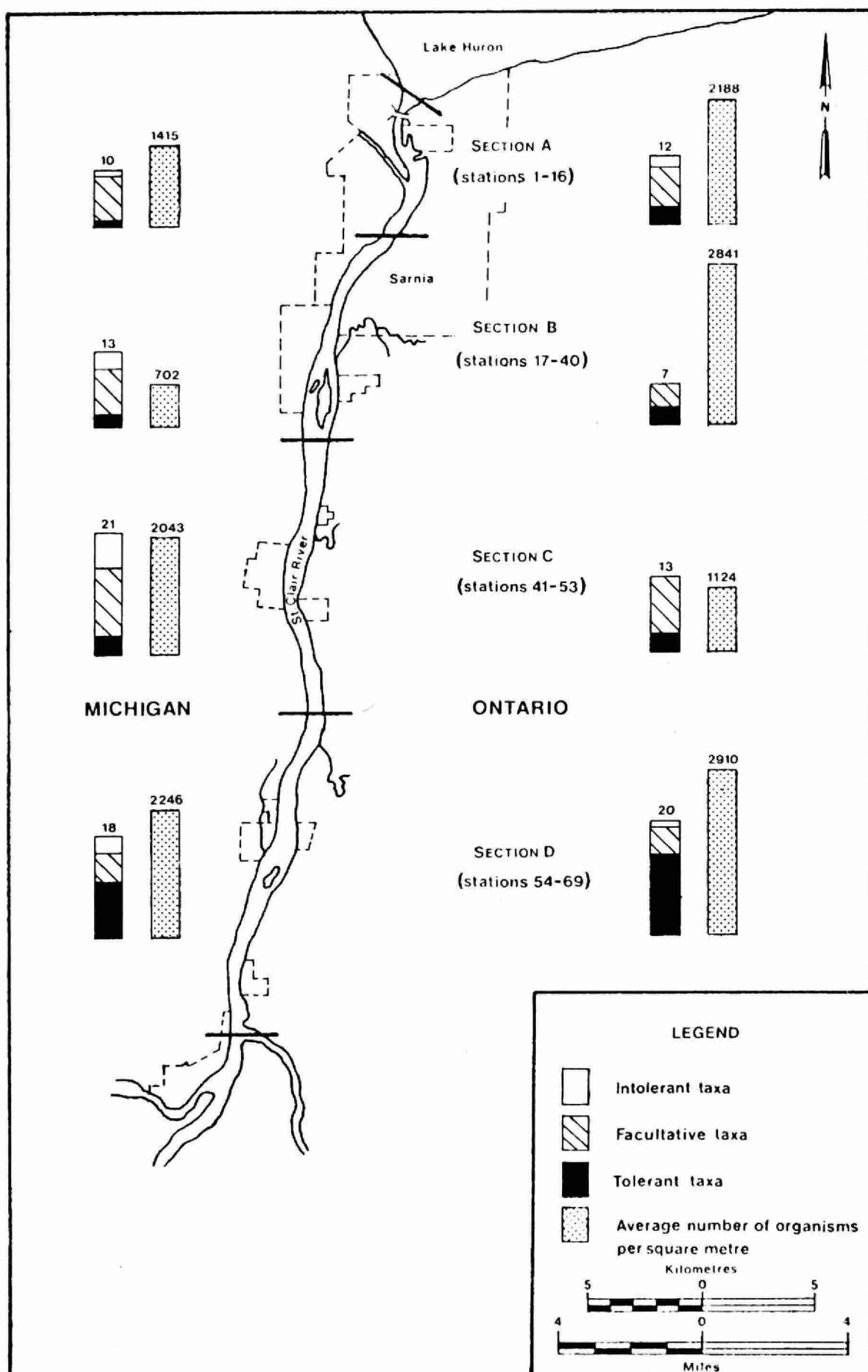


Figure 4. Average number of taxa per station and organisms per  $m^2$  in 4 major sections of the St. Clair River, May - June, 1977.

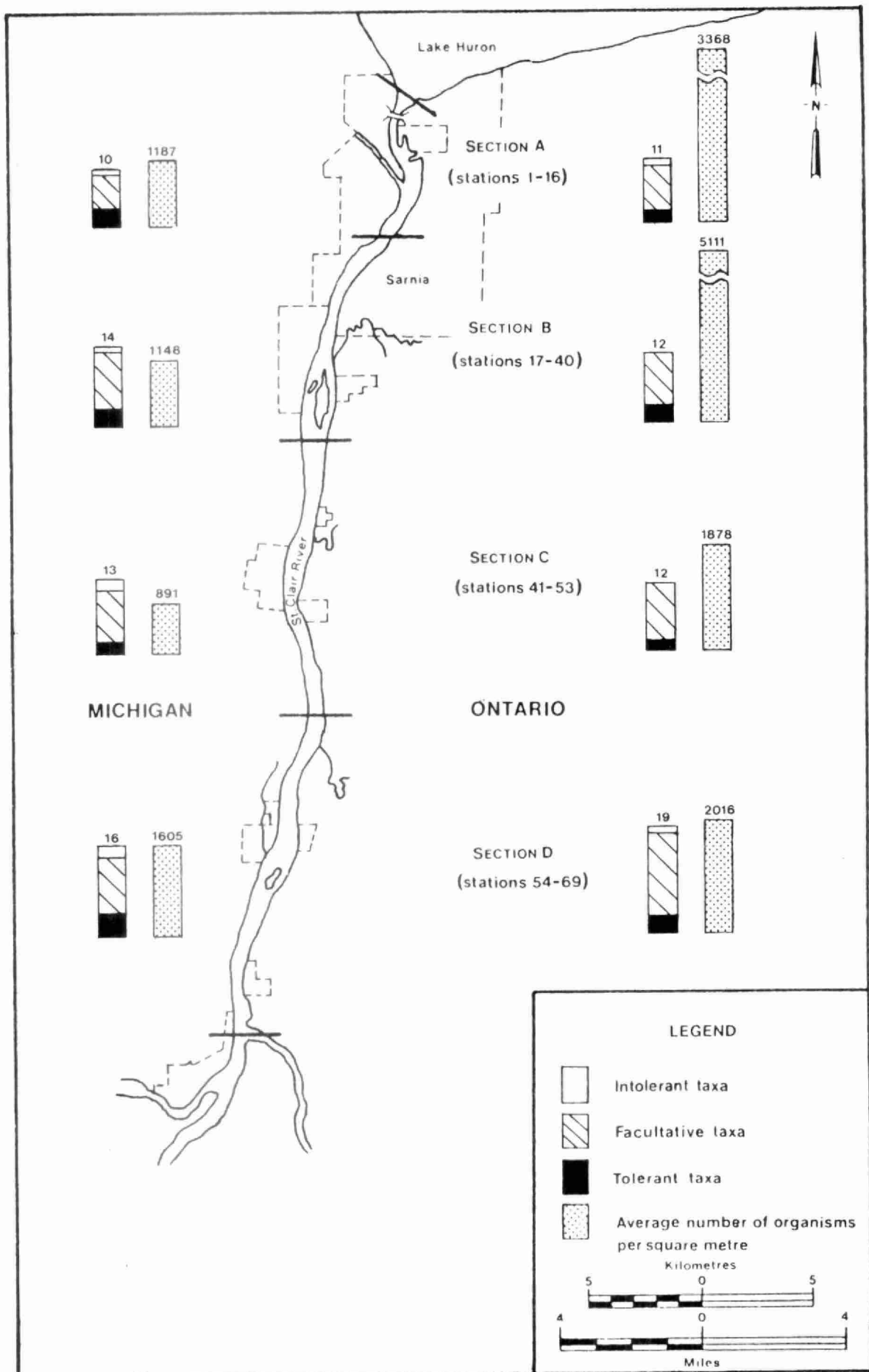


Figure 5. Average number of taxa per station and organisms per  $m^2$  in four major sections of the St. Clair River, July-August, 1977.

procedures. As a first step the organisms were ranked using a dispersion criterion (after Orloci, 1973) which calculated each taxon's portion of the total community dispersion and thereby each taxon's relative importance (information). The top ranking species (28 taxa) were retained for further analysis along with an estimate of the total information retained.

These taxa or organisms were then subjected to a multivariate association (cluster) analysis (after Williams and Lambert 1959) which produced clusters or associations of organisms. The distribution of these associations was then mapped (Figure 6).

To supplement the macroinvertebrate data additional information was collected at the time of the survey. This information was used to look for differences in sediment and water quality between associations and hence a reason for the clustering.

Samples of water were collected one metre below the surface on six occasions in 1977 and analysed for: total and suspended solids, total and soluble phosphorus, free ammonia, total Kjeldahl nitrogen, nitrite and nitrate nitrogen, total carbon, inorganic carbon, conductivity, chloride, alkalinity, hardness and pH. Samples of water were collected on one occasion and analysed for vinyl chloride.

Sediment samples were collected on a single occasion and analysed for: solvent extractables, numbers of heterotrophic bacteria, sediment composition, loss-on-ignition, PCBs and mercury.

These quantitative data were analysed using analysis of variance (ANOVA) and the Student-Newman-Keuls (SNK) test of means. Results of the SNK tests are presented in Figure

Figure 6. Distribution of benthic associations, 1968 and 1977.

7. Associations underscored by continuous or overlapping lines do not have significantly differing mean values. Only those parameters where a significant difference was detected are included in Table 1.

Other data were also recorded on a present/absence basis and analysed using a test of independence (Table 2).

On the basis of all statistical analyses, a relative tolerance to pollution was assigned to each association (Figure 7). Association 5 was judged the most tolerant to pollution since; it was associated with sites with direct visual (presence of oil or grease) and/or olfactory (petrochemical odour) evidence of pollution of the sediments; was found at sites with higher conductivity readings, higher chloride concentrations and lower diversity indices; and was associated with bacterial slime growths. Associations 2 and 4 were judged the next most tolerant to pollution. Association 2 was associated with sites exhibiting direct evidence of pollution in the sediments and associated with the presence of aquatic plants (a sign of enrichment). Association 4 was associated with the presence of aquatic plants and was found at sites with higher concentrations of vinyl chloride in the water, higher numbers of heterotrophic bacteria in the sediments and higher percent loss-on-ignitions for the sediments. Associations 1 and 3 were found at sites with little evidence of pollution. Association 7 was essentially confined to the deeper waters and coarser sediments of the shipping channel.

Knowing the distribution of associations and now knowing the relative pollution tolerances of the associations, the river was divided into zones of water quality based on association distribution (Figure 8).

Table 1. Results of Student-Newman-Keuls test of means  
for data collected from the St. Clair River  
during 1977.

# PHYSICAL

Depth (metres)

F = 29.28\*

|                 |     |     |     |     |     |     |
|-----------------|-----|-----|-----|-----|-----|-----|
| Association No. | 1   | 4   | 2   | 5   | 3   | 7   |
| Mean            | 1.8 | 2.8 | 4.1 | 4.7 | 4.8 | 7.3 |

Sediment Grain Size (relative units) F = 37.81\*

|                 |     |     |     |     |     |     |
|-----------------|-----|-----|-----|-----|-----|-----|
| Association No. | 1   | 2   | 4   | 3   | 5   | 7   |
| Mean            | 2.4 | 2.5 | 2.7 | 2.7 | 2.8 | 3.4 |

# CHEMICAL

Loss on Ignition (%)

F = 7.36\*

|                 |      |      |      |      |      |     |
|-----------------|------|------|------|------|------|-----|
| Association No. | 7    | 3    | 2    | 1    | 5    | 4   |
| Mean            | 3.31 | 3.68 | 4.04 | 4.32 | 4.54 | 5.9 |

\* indicates a significant F value at  $p < 0.01$

\*\* indicates a significant F value at  $p < 0.05$

NOTE: Association means underscored by continuous or overlapping lines are not significantly different.

CHEMICAL - continued

Conductivity (umho/cm at 25°C) F= 5.84\*

|                 |     |       |       |       |       |       |
|-----------------|-----|-------|-------|-------|-------|-------|
| Association No. | 3   | 1     | 4     | 2     | 7     | 5     |
| Mean            | 222 | 222.7 | 223.5 | 224.5 | 225.3 | 243.6 |

---

Chloride (mg/l) F = 5.16\*

|                 |      |      |      |      |      |      |
|-----------------|------|------|------|------|------|------|
| Association No. | 2    | 4    | 7    | 3    | 1    | 5    |
| Mean            | 10.7 | 10.8 | 11.1 | 11.4 | 12.8 | 16.2 |

---

Vinyl Chloride (µg/l) F = 4.94\*

|                 |      |      |      |      |      |      |
|-----------------|------|------|------|------|------|------|
| Association No. | 5    | 7    | 1    | 3    | 2    | 4    |
| Mean            | 8.62 | 9.59 | 10.3 | 11.4 | 11.9 | 30.3 |

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BIOLOGICAL

Heterotrophic Bacteria (numbers/ml x 10<sup>3</sup>) F = 7.9\*

|                 |       |       |        |        |        |        |
|-----------------|-------|-------|--------|--------|--------|--------|
| Association No. | 7     | 5     | 2      | 1      | 4      | 3      |
| Mean            | 899.0 | 919.8 | 1163.4 | 1548.9 | 3738.9 | 3835.8 |

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Diversity Index (Wilhm 1970) F=21.7\*

|                 |      |      |      |      |      |      |
|-----------------|------|------|------|------|------|------|
| Association No. | 7    | 5    | 4    | 3    | 2    | 1    |
| Mean            | 1.22 | 1.67 | 2.36 | 2.54 | 2.59 | 2.72 |

---

Table 2. Relationship of benthic associations to environmental factors.

| Environmental factors                                               | Association number |    |    |    |    |   |
|---------------------------------------------------------------------|--------------------|----|----|----|----|---|
|                                                                     | 1                  | 2  | 3  | 4  | 5  | 7 |
| Presence of oil, grease and/or petrochemical odour in the sediments | ns                 | +  | ns | ns | +  | - |
| Presence of aquatic plants                                          | +                  | +  | ns | +  | ns | - |
| Presence of bacterial slime growth                                  | ns                 | ns | ns | ns | +  | - |

ns non-significant  
 + associated  
 - independent



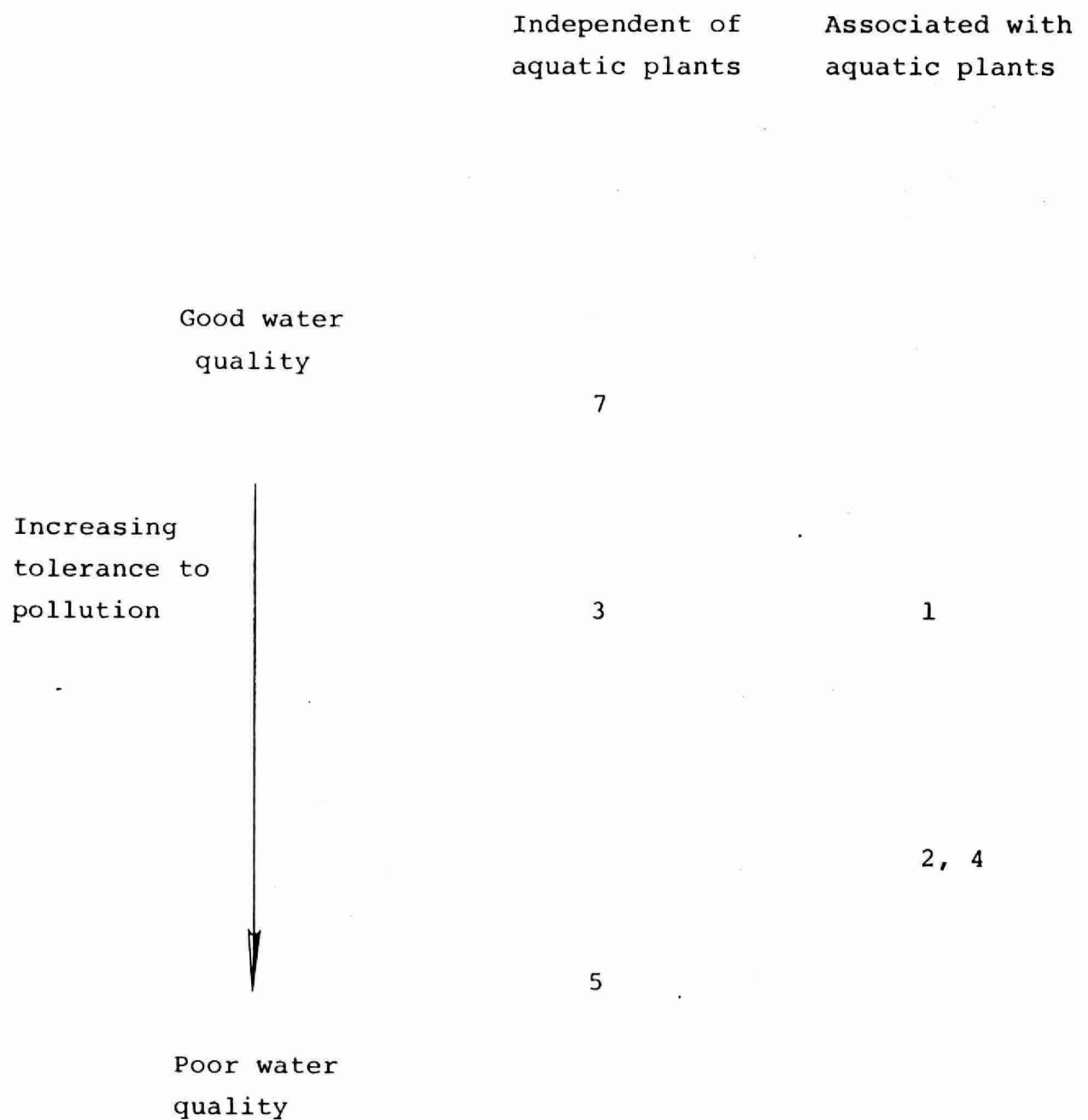


Figure 7. Pollution tolerances of benthic associations in the St. Clair River.

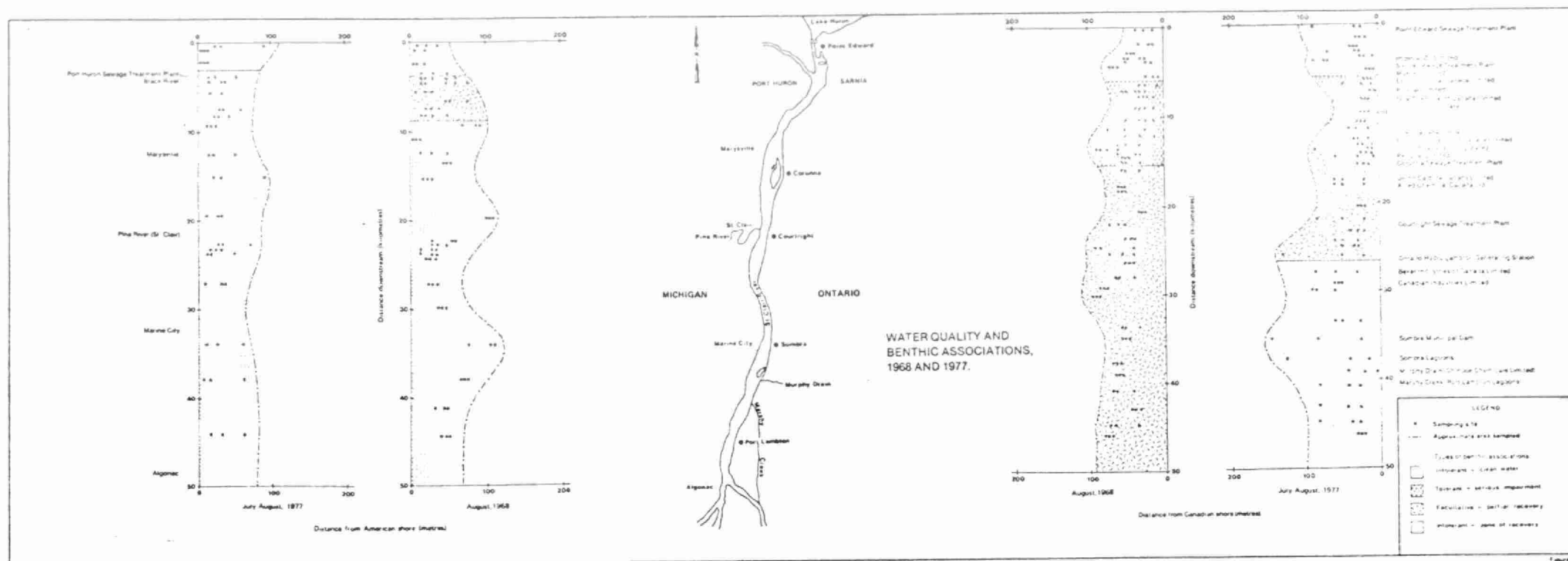


Figure 8. Water quality and benthic associations, 1968 and 1977.

The results of this method of analysis compares very favourably with the analysis of species numbers and variety. A zone of serious water quality impairment was present along the Canadian shore of the river in both 1968 and 1977. In 1968 the river had only partially recovered from this impairment whereas in 1977 further and virtually complete recovery was evidenced. Also in 1977 the extent of the zone of serious impairment was markedly reduced.

In summary therefore:

1. Zones of serious water quality impairment were documented along the Canadian side of the river both in 1968 and 1977. In 1977 however the pollution of this zone was not as severe or as extensive as reflected by the invertebrate macrobenthos.
2. Virtually complete recovery of the macroinvertebrates, as evidenced by the re-establishment of organisms intolerant to pollution, occurred in 1977 along the Canadian shoreline. The river exhibited only partial recovery during 1968. The further recovery exhibited in 1977 is attributed to the improvements made in the quantity and quality of industrial and municipal discharges over the corresponding period.
3. Additional improvements should be encouraged since a zone of serious water quality does still exist and since the river biota has demonstrated the ability to respond positively to the pollution abatement programs already implemented.

Use of Low Grade Heat From  
Electrical Generating Stations  
by  
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Ontario Hydro  
Toronto

Introduction

Ways of utilizing the low grade heat in the large volumes of condenser cooling water discharged from thermal electric generating stations have excited the interest of scientists, entrepreneurs and electrical utilities for many years. However, low grade heat has not been exploited to any marked degree, and the numerous reasons for this are reviewed and discussed. In the CANDU nuclear plant a higher and more uniform temperature cooling water stream can be isolated which promises to be economically attractive for use in heating such facilities as greenhouses.

The high price of heating fuel and the need to conserve energy resources are making many industries aware of their own waste heat streams. After in-plant conservation of energy, the remaining low grade heat streams could be considered for uses external to the plant, and some of these applications are described.

Sources of low-grade heat from thermal generating stations

Although modern steam electric power plants employ among the most efficient boilers and heat engines available, a substantial amount of the heat released by the fuel is rejected or lost at low temperature to the surrounding environment. With the exception of noise emission, all losses in the energy conversion processes used to generate electricity leave the plant as heat. The Sankey diagrams (12) in Figures 2.1 and 2.2 indicate typical proportions of such heat for a large fossil and nuclear plant respectively. Although these diagrams indicate the overall conversion efficiencies to be about 37 percent for fossil fuelled plant and 29 percent for nuclear fuelled plant, it is important to note that in relation to the theoretically ideal efficiencies (Carnot efficiency) these plants are between 60 and 70 percent efficient.

For a large US bituminous coal-fired fossil plant about 20 percent of the losses are boiler and stack losses and most of the remaining 80 percent occurs as rejected heat at the turbine condenser. The boiler losses result mainly from combustion inefficiencies. Losses up the stack are due to the need to have sufficient exhaust temperature to maintain adequate draft and to prevent condensation of corrosive gases on the metal chimney flue. Rejected heat loss at the turbine condenser results from practical considerations that require the turbine working fluid, water, to be returned to the boiler as a pressurized liquid. The condenser reject

heat is therefore mainly the latent heat of the turbine steam exhaust. High efficiency of the turbine is achieved by a relatively small cooling water temperature rise across the condenser. In practice, therefore, the temperature of cooling water discharged from the power plant is about 10C above intake water temperature. In winter, when the cooling water inlet is 2C to 4C, this increase in temperature across the condensers results in cooling water discharge temperatures generally less than 15C.

For nuclear fuelled generating stations, about 89 percent of heat loss is rejected heat at the turbine condenser, 7.5 percent is rejected heat by the moderator cooling system and the remaining 3.5 percent mainly from mechanical and electrical losses. Moderator reject heat is unique to the CANDU reactor design. It results from the relatively low temperature heating of the reactor structure and moderator heavy water surrounding the nuclear fuel. Essentially, any energy released by the fuel fissioning and not absorbed in producing steam for electric power production is removed from the reactor as heated moderator water. Outside the reactor, the moderator water is cooled in large heat exchangers by the station service water and the heat is rejected from the station, together with the condenser reject heat, usually in a common cooling water outflow channel. The heated moderator cooling water is at fairly constant temperature year round, approximately 40C in winter and 35C in summer from the existing Pickering and Bruce generating stations.

Table 2.1 summarizes the quantities and temperature of waste heat sources from typical large fossil and nuclear power plants operated by Ontario Hydro. Generally in Ontario, fossil fuelled plants operate at considerably lower capacity factors than nuclear plants with the result that waste heat from nuclear plants is available on a more continuous basis. The current practice of building multiple unit generating plants would ensure redundant or backup supplies of heat for most heating applications. As an example, the moderator heat capacity of single generating unit of a large four unit base-load nuclear plant would have an estimated availability in excess of 99 percent (three units as back-up). This high availability combined with the significant quantities and year round temperatures at or near 40C make moderator reject heat the most attractive waste heat source currently available from Ontario Hydro power plants and a significant effort is being made to find and put in place applications to use this heat.

Table 2.1

Waste Heat Effluents From Typical Generating Stations

| Source                        | Quantity and Temperature of Waste Heat Effluents                                       |
|-------------------------------|----------------------------------------------------------------------------------------|
| <u>3000 MWe Fossil Plant</u>  |                                                                                        |
| a) Boiler and Stack Losses    | 2,500 m <sup>3</sup> /s flue gas @ 150C                                                |
| b) Condenser Reject Heat      | 90,000 l/s cooling water @ 27C in Summer<br>90,000 l/s cooling water @ 13C in Winter   |
| <u>3000 MWe Nuclear Plant</u> |                                                                                        |
| a) Condenser Reject Heat      | 155,000 l/s cooling water @ 27C in Summer<br>155,000 l/s cooling water @ 13C in Winter |
| b) Moderator Reject Heat      | 7,900 l/s cooling water @ 40C in Summer<br>3,660 l/s cooling water @ 35C in Winter     |

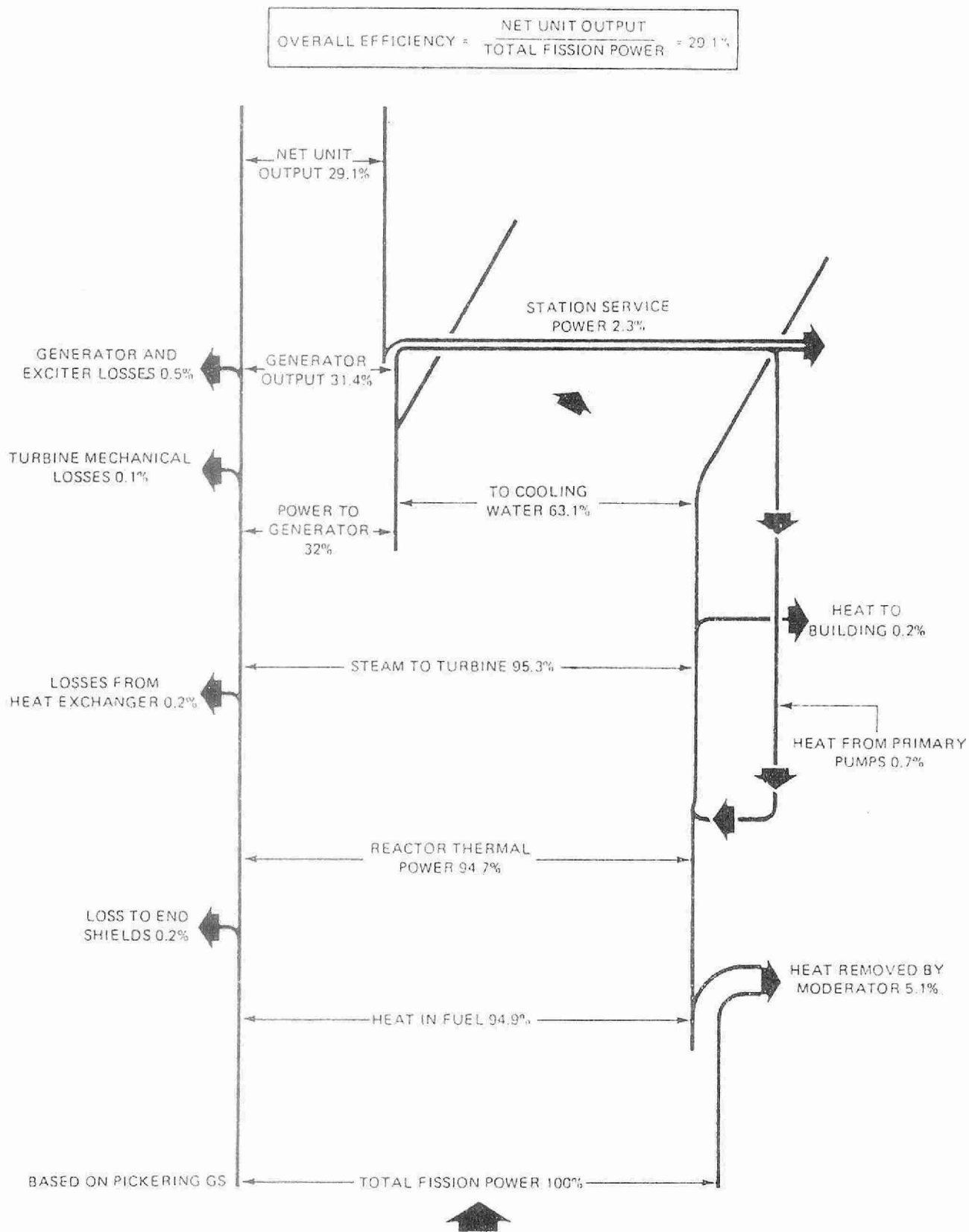


FIGURE 2.2 ENERGY DISTRIBUTION IN A TYPICAL NUCLEAR FUELLED GENERATING STATION

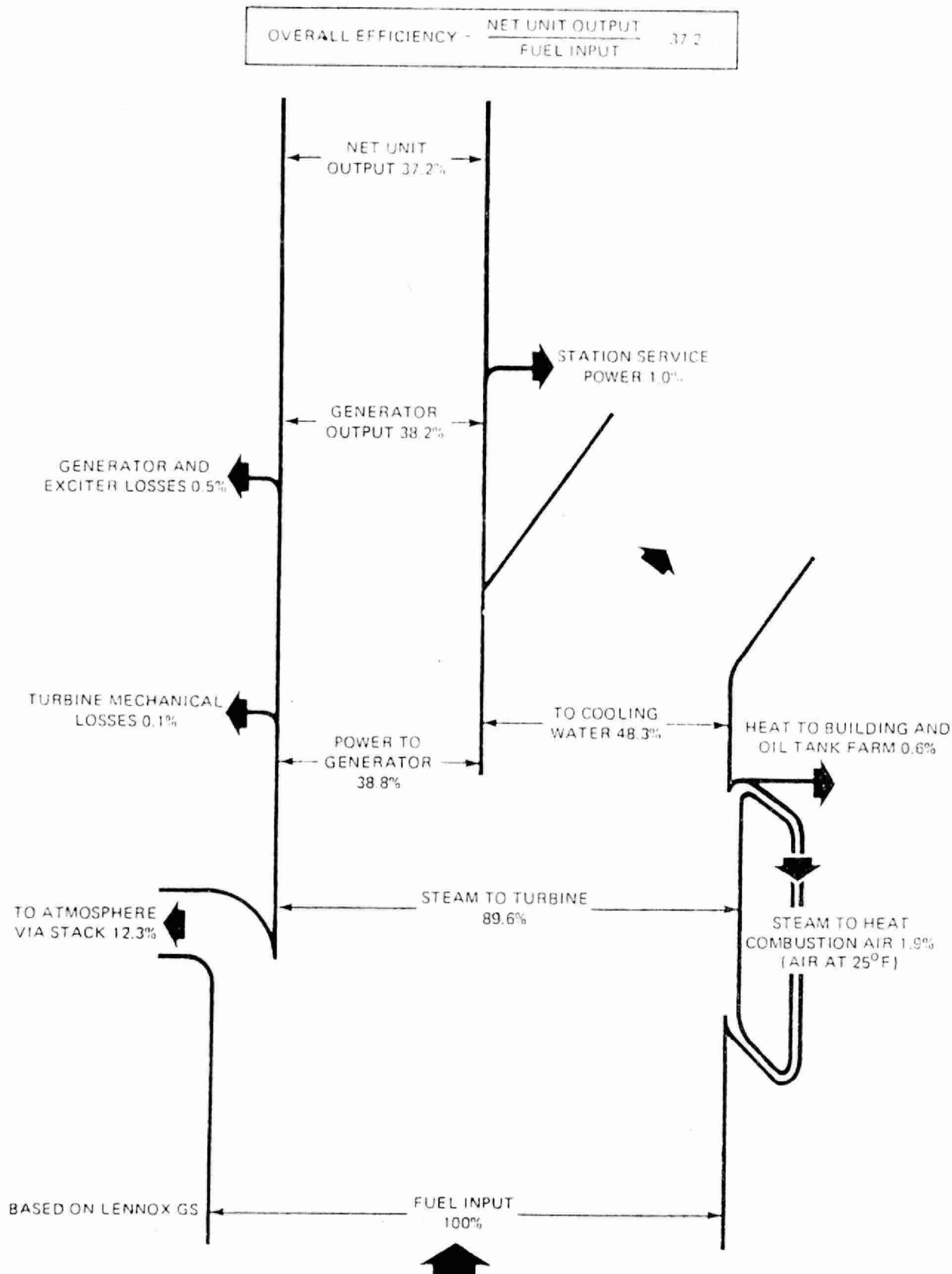


FIGURE 2.1 ENERGY DISTRIBUTION IN A TYPICAL FOSSIL FUELLED GENERATING STATION



## Sources of higher temperature heat from thermal generating stations

In addition to the low temperature waste heat from the sources outlined in Section 2.0, higher temperature heat can be made available from a number of other points in thermal generating plants. Taking heat from these points would generally result in reduced electrical generation capacity and efficiency, but usually it can be reasoned that as a supplier of both heat and electricity the total capacity and overall efficiency of the plant is improved. Ontario Hydro is currently examining possible sources for higher temperature steam heat from its existing steam electric power plants (22). When completed, the study will provide information on costs, available quantities and steam conditions for a number of points on the turbine power cycle. These include such sources as turbine extractions, turbine crossover and reheated outlet.

The determined costs to the utility to provide heat from these sources include consideration of the reduced electrical capacity of the turbine generator and the possible cost of operating the station to supply heat when it normally would not be required for electric power generation. These considerations require charges to be allocated to the heat supply for costs of replacement electric energy and capacity and in some cases for the added cost to the electric power system for operating the plant out of order-of-merit (the order in which plants are brought on load to meet electrical demand). In Ontario, the out-of-merit cost penalty would often apply to heat sources from fossil fuelled power plants and can be as high as 60 \$/MWh of steam heat supply from low order-of-merit plants such as Keith GS. At the present time, nuclear plants are used for base load operation in Ontario with the result that out-of-merit operating penalties would not apply to nuclear steam heat supplies. The major cost component for steam heat from such plants as Pickering and Bruce nuclear generating stations would be for replacement of the lost electricity generation. This replacement would normally come from coal-fired fossil generation. The study results to date show steam heat supply costs from fossil-fuelled generating stations to range from slightly less to considerably more than the fuel cost for steam from a conventional natural gas fired boiler. For nuclear plant heat, the costs range from about one third to close to the cost of the conventional steam fuel cost.

In addition to supplying heat from points on the turbine power cycle, main steam directly from the boilers or steam generator of fossil and nuclear power plants can be used to

supply heat to external heat loads. An example of using nuclear main steam exists at the Bruce Nuclear Power Development where an interconnecting steam supply system between the heavy water plants, an oil fired steam plant, Douglas Point GS and Bruce GS A allows nuclear main steam to be used as a source of process heating to the heavy water plants. This system has a connected capacity of approximately 1200 MWt from the steam generators of Bruce GS A.

Previous and ongoing discussion have been held with potential users of nuclear main steam from various planned and existing Ontario Hydro nuclear power plants. Generally the heat loads being considered are of significant size and the costs of supply for the heat are very competitive with conventional fuel process heat. Preliminary estimates to supply 450,000 Kg/hr of process steam from nuclear main steam to a potential industrial heat load have indicated steam costs to the customer's premises that are about 90 percent of the fuel cost of a conventional fuel boiler alternative.

Important factors that will have a determining influence on the attractiveness of using higher temperature heat include the distance between the generating plant and customer's facility and the size and load factor of the heat load. In general terms, large heat loads with high load factors that can be located within a few miles of large multi-unit nuclear plants can, even today, expect to achieve significant savings using process steam. These savings can be expected to come from not only lower annual heat cost but also from lower expected annual rates of escalation for the heat.

Major studies that have or are addressing the use of higher temperature heat from Ontario Hydro's thermal power plants include the following:

- (a) the North Pickering district heating study (23) which examined using off-peak nuclear steam from the turbine cross-over of Pickering GS as a district heating supply to the planned community of North Pickering
- (b) a planned study on the feasibility and implementation of extraction steam from Pickering GS as a district heating supply to the first phase of the planned North Pickering Community
- (c) an ongoing study of the feasibility of installing refuse boilers at R.L. Hearn GS to both generate electricity and to supply steam to the Toronto District Heating System

## The use of low-grade heat in Ontario

### Production and experimental fish hatchery at Lennox generating station

In 1970 the Ministry of Natural Resources (then the Department of Lands and Forests) proposed a fish hatchery at the Lennox generating station, near Kingston. The preliminary design was administered by the Ministry of Government Services whose consultant, Underwood-McLellan and Associates, Ltd., in 1972 proposed a first phase annual production of 150,000 to 200,000 lbs of cold water fish species. A maximum annual production rate of 800,000 lbs was planned. Modifications were made to the generating station pump house for the installation and piping of the cold and warm water supply to the hatchery.

The rapid escalation of oil prices, starting in 1973, sharply reduced the anticipated capacity factor of the proposed generating station. The source of heated water from the station therefore became less available than had originally been anticipated. As a result of this change, four alternate systems were proposed by the consultant in 1975 to allow the hatchery to have varying degrees of independence from the generating station cooling water discharge supply. Since that time the project has not moved ahead due to developing doubt about the Lennox site being the best for such a hatchery operation. Also the cost of the project would now take up a large proportion of the Ministry of Natural Resource's budget. The adoption of such a project would delay several other high priority but smaller projects.

### Siting of an aquaculture facility at a nuclear generating station

In 1974 Environment Canada, Fisheries and Marine Services, financed a feasibility study on the siting and development of an aquaculture facility at an Ontario Hydro nuclear generating station (1). The program was supervised by a steering group comprised of members of the Federal Government, Ontario Ministry of Natural Resources, Ontario Hydro and Atomic Energy of Canada Ltd. This facility was to be considered initially for:

- fish production for food
- production of certified fish stocks
- production hatchery to aid in Great Lakes rehabilitation
- on-site training
- fish stock selection
- recreational uses including an aquarium
- production of bait and ornamental fish

- production of test species
- research on nutrient recycling and fish food production
- education and teaching.

The feasibility study included the selection of the most suitable location from three nuclear generating sites, Pickering, Bruce and Darlington, examination of engineering constraints and a conceptual engineering study of the facility to meet the above requirements. The technical and economic feasibility of an intensive culture salmonid hatchery and an associated research facility were assessed for each site. Four production levels ranging from 100,000 to 500,000 lbs per year were considered for the hatchery. The Bruce site was the preferred site based primarily on water quality and offshore temperature conditions. One interesting problem encountered was that in about one or two weeks of the year the lake temperature at the 12 metre depth of the intake would exceed 21C which is considered excessively high for maintaining salmonids. The optimal temperature for growth of about 15C is exceeded in the three summer months July, August and September. A cooler water source is therefore essential for year-round rearing program. The economics of installing a deeper intake pipe and on-site chilling of water were compared and the former found to be preferable at the scale of production planned.

One major conclusion from this study was that the Great Lakes rehabilitation portion of the program would be economically competitive with the private sector's programs at certain levels of fish size and production rates.

Forty acres of property at Bruce was designated for this development and has been held by Ontario Hydro since 1976. However, this program is now considered to be deferred indefinitely due to financial constraints.

#### Feasibility study for Ontario agriculture

In 1973 Ontario Hydro, in conjunction with Atomic Energy of Canada Ltd., Ontario Ministry of Agriculture and Food, and Agriculture Canada, supported a feasibility study at the University of Guelph, on the agricultural uses of waste heat (2). Results indicate that the relatively low temperature of cooling water discharge would not be economically feasible to grow cool temperature crops using a closed heat exchange system in a greenhouse. However, with a direct contact heating system, temperatures could be kept to within 6C of discharge water temperatures even in very cold ambient conditions, allowing such crops as tomatoes to be grown during the period April - November, and lettuce during the

winter months. The economics of such systems were found to be critically dependent on the distance between warm water source and the greenhouse because of the high cost of pumping and piping. In this report the use of the moderator cooling water circuit from the CANDU reactor was recommended as a potentially more valuable source of higher and more consistent temperature water for greenhouse heating.

#### Planned projects to utilize moderator heat

As noted above and in Section 2.0, the availability, quantities and temperature of moderator heat make it attractive as a heating energy resource. Greenhouses, fish farms and residential district heating are possible applications that have been considered. The successful demonstration of finned-coil air handlers to utilize 30C power plant cooling tower waste heat in the SHERCO greenhouse (15) at Northern States Power's Sherbourne County plant in Becker, Minnesota, gave considerable impetus to use moderator heat in similar projects in Ontario. Present plans of Ontario Hydro and the Ontario Government call for commercial greenhouse developments utilizing moderator heat from both Bruce and Pickering generating stations. A local initiative by the town of Kincardine to attract industry to the Bruce area has been chiefly responsible for the plans to site a major greenhouse development in that area. The initiatives resulted in an Ontario Government financed consultant's study in 1977 (16) on the feasibility of locating the greenhouses and fish farms near the Bruce generating stations. At Pickering the planned greenhouses were proposed by Ontario Hydro.

When finished, Ontario Hydro's two large nuclear plants at Bruce could heat over 200 ha of greenhouses using the moderator heat, and the eight unit Pickering station will produce enough heat for about 120 ha. Depending on the size of the greenhouse developments and their distance from the generating stations, moderator heating is expected to cost between one quarter to one half of conventional fuel costs, which are currently about \$90,000 per ha year.

Because of rapid residential and industrial development on land surround the Pickering generating station, the plans of Ontario Hydro and the Ontario Energy Corporation call for only a small 3 ha commercial greenhouse located on Hydro property near the generating station. At Bruce however, the plans are for an initial commercial development of up to 40 ha in size with the possibility of fish farms being included in the development. Current scheduling would see the 3 ha Pickering greenhouse in operation in early 1981, and the larger Bruce development approximately one year later. Combined, the two developments would be capable of



growing enough tomatoes to replace about 25% of current imports into Ontario.

Both developments are being preceded by a small demonstration greenhouse at each site. At Pickering, a 200 square metre plastic covered greenhouse, paid for and erected by Ontario Hydro, has been in operation since mid February. It will be in operation for one year and is being used to test the finned-coil heat exchanger equipment required to utilize the relatively low temperature moderator heat. In addition, tomato, cucumber and lettuce crops grown in the greenhouse will be subject to analysis to verify market quality and obtain data necessary to gain government approvals for the commercial greenhouses. At Pickering, the commercial greenhouse site is on land that will require licensing by the Atomic Energy Control Board. At Bruce, a 0.4 ha demonstration greenhouse is being planned by the Ontario Energy Corporation, for construction before the end of this year and will be located on the site for the 40 ha commercial development. The site has been chosen and is approximately 11 kilometers from the Bruce A generating plant. This demonstration will be a showcase aimed at attracting greenhouse growers to the large commercial development by demonstrating the productivity potential of greenhouses located at Bruce. Such things as snow loads, the adequacy of sunshine and performance of the unique heat exchange equipment will be demonstrated. As at Pickering, moderator cooling water temperatures will be simulated using a conventional boiler.

Substantial amounts of capital financing are required for both projects. At Pickering, a commercial greenhouse grower will finance and erect the greenhouse buildings and equipment. Ontario Hydro will lease the site and finance and build the warm water pipeline from the generating station to the greenhouse. Hydro's costs will be recovered through charges for the warm water. The greenhouse and equipment are expected to cost 1.6 million dollars, and Ontario Hydro will spend close to 1 million dollars. At Bruce, the proposed 40 ha development would require approximately 40 million dollars of private sector financing and about 7 million dollars by Ontario Hydro. A unique private sector consortium has been formed by the Ontario Energy Corporation to finance and build the Bruce demonstration and commercial development. As planned, greenhouse growers will be able to lease or purchase finished greenhouse space in four acre (1.6 ha) blocks from the development consortium. The consortium and leasing arrangements are designed to attract private sector financing and to allow small business and greenhouse growers to participate in the project.

## Possible future applications for moderator heat

Aside from greenhouse heating, significant potential is seen for moderator heat in other forms of building heating, including residential district heating. Hydro has recently modified the design of both Bruce B and Darlington generating stations to allow moderator heat to be supplied at slightly higher temperatures that would be necessary for home heating. A recent Ontario Hydro report (9) indicates that houses up to 16 km from the planned Darlington generating station could be heated in this way at a cost less than electrically heated homes.

Current studies are continuing to evaluate this application as significant advantages are foreseen over more conventional higher temperature district heating schemes. These include:

- A low cost heat source at the power plant,
- A potentially lower cost hot water transmission and distribution piping system utilizing concrete pipe,
- Increased feasibility to have smaller initial developments.

An alternative proposal for district heating with moderator heat involves domestic water supply preheating with moderator heat and heat extraction in homes using water-to-air heat pumps. This concept is one of the variations proposed by Energy, Mines and Resources Canada (21) and has been examined in further detail by Ontario Hydro. This district heating approach, however, appears likely to be restricted by problems it would impose on the domestic water supply system.

### The use of low grade heat from thermal generating stations in the rest of Canada

#### Aquaculture

The only significant aquaculture production for human consumption in Canada is the culture of trout in prairie pothole lakes (14). Elsewhere, various government hatcheries are involved in the production of fish stocks for sports or commercial purposes. However, the only known operating facility in Canada which uses artificial heat to enhance growth rates is at the Grand Lake generating station in New Brunswick where brook trout are grown in cages in the thermal discharge (11). The facility has been operating for four years and approximately 50,000 fish were planned to be

grown in the 1977-1978 season. The Canadian Electrical Association, New Brunswick Ministry of Natural Resources, New Brunswick Power, and New Brunswick Coal have just financed research and development of a larger facility at the generating station with an annual planned production of 175,000 brook trout and atlantic salmon. This operation is expected to get underway in 1979.

Also in New Brunswick a feasibility study was carried out in 1974 for a facility to use the thermal discharge from the Coleson Cove generating station at Lorneville for production of trout or salmon (10). Originally, this was one of several industries planned in an industrial park near the generating station. The aquaculture facility was not attractive economically because it was to be located some distance from the generating station and had high pumping and piping costs. The industrial park is apparently not going ahead as planned, so the possible relocation of the aquaculture facility closer to the station would make it more attractive.

There has been little activity with the atlantic salmon aquaculture facility proposed for the Point Lepreau nuclear station, New Brunswick in 1974. However, it is still possible that the project will go ahead. The Lorneville site was to be used for testing out the design and operating aspects of this facility.

Finally, in New Brunswick is the facility at Grand Manaan where locally harvested dulse is placed in tanks in the winter receiving warm discharge water from the generating station. Growth of the alga is increased by the elevated temperature. The tanks are also used as holding vessels before the product is naturally dried out.

The remaining project known to have been considered in the Maritimes is the aquaculture facility at the oil-fired Holyrood generating station in Newfoundland. Although pumping and holding facilities were built, the project has not gone ahead because of the low operating capacity factor of the generating station since 1970. This situation appears to be very similar to the one at Ontario Hydro's oil-fired generating station at Lennox.

In Alberta, a feasibility study was carried out on a aquaculture facility at Grand Cache which would have raised one million kg of trout annually and used some thermal effluent from the H.M. Milner generating station (13). Again, this project did not get beyond the feasibility stage, possibly due to the doubtful economics.



At the Sundance generating station of Calgary Power, a small trout rearing facility off the main cooling pond was developed. Problems with freezing has forced the operator to temporarily close down.

### Agriculture

In Alberta a greenhouse was installed at the Wabamun generating station of Calgary Power using the condenser cooling water as a sole source of heat. The heat was transferred to the greenhouse by blowing air across fibrous matting down which the warm water flowed. In very cold weather the resulting saturated atmosphere produced a fog which limited light penetration for growth of the tomatoes, cucumber and conifer seedlings. An additional problem was that fungal infection occurred at these high humidities. Although adequate temperature were shown to be capable of being maintained by such a system the fog, condensation and incidents of infection made this operation impractical.

In 1975 a feasibility study by the Atomic Energy of Canada Limited at Whiteshell using the moderator heat from a CANDU nuclear reactor showed that 10 ha of greenhouses could not be economically competitive with the then price of fuel oil (23¢ gallon) conventional heating. The major capital cost was the modification of the moderator cooling circuit and piping of the warm water to the site (19).

The costs and market potential of a 1977 feasibility study of the use of waste heat from the Glace Bay heavy water plant for greenhouse production of vegetables appeared attractive. However, the company interested in this project has not been able to get the necessary financial support.

### Miscellaneous

One of the most interesting uses of waste heat from a generating station is the blending of condenser cooling water with cold river water by the City of Edmonton to achieve a water supply temperature of 12C. This has been done since 1950 and no problems have been reported in the distribution or consumption of the water. This system saves approximately \$250,000 annually in water treatment plant chemicals. Additional savings due to reduced water main breakages are claimed. The main savings, however, are the reduced water heating costs for consumers.

At the Whiteshell Nuclear Research establishment in Pinawa, Manitoba, waste heat from the nuclear research reactor is now used as the main heat source for offices and laboratories.

Oil-fired boilers are kept as backup. Also, at the Chalk River nuclear reactor, heat from one of the in-reactor loops has been used for heating boiler water feed since 1975. Since 1977, steam is being raised from an in-reactor loop for heating and humidifying the research unit buildings.

Problems of integration with  
the low grade heat source

Many writers on low grade heat utilization emphasize the vast volumes produced from generating stations on a national or regional basis and often translate these volumes and temperatures into the equivalent number of barrels of oil lost to the economy. This approach tends to be misleading on two accounts. Firstly, it does not consider the low temperature and hence the thermodynamic usefulness of the condenser cooling water discharge. Typical discharge temperatures of 11C for several months in the winter are not very useful sources of energy for doing work and useless for such things as heating a greenhouse air space to 21C. Secondly, it is implied that a large proportion of this admittedly vast amount of low grade heat could be effectively used in some large undertaking. However, the moderator thermal discharge from the 8 unit Pickering generating station could theoretically supply the peak heat demand for 120 ha of greenhouses. As the present areas of greenhouses in Ontario and Canada are approximately 140 ha and 300 ha respectively, the economic and social impacts of such an installation on the existing greenhouse industries would be immense. Similarly, an aquaculture facility could be supported by this size of generating station which would supply far more than the provincial consumption of fish. A reasonable size of greenhouse or aquaculture facility at a generating station would therefore use only a very small fraction of the supplied heat and would barely influence the amount of heat that has to be eventually dispersed to air or water. This is particularly true when one considers that a facility would not require the heated discharge for a large part of the year. As an example, the application of greenhouse heating is capable of only extracting less than 20% of the available heat in the moderator cooling water.

In a 1978 state of the art review for the Edison Electric Research Institute (4) it was stated, "numerous research and feasibility studies have been conducted, but few commercial enterprises were using condenser cooling water at the time of study". In a 1975 paper (20) a fairly long list was presented of those factors to be taken into account when considering integration of a low grade heat facility with a

utility's cooling water discharge. These several factors provide some explanation for the slow progress in the whole area of low grade heat utilization. Of these previously recognized factors, the most important still are: recognition of the reliability and availability of the warm water source, possible deterioration of the water quality from the user facility, large differences in lead time for design and construction of a generation station and the warm water facility, and finally, the relatively difficult problem of serving the economic and social interests of the utility, user, regulatory agency and other interested groups. In the light of recent experience, this latter problem appears to be a far more difficult one to overcome than any technical factor.

Most economic feasibility studies of applications for utility waste heat have been based on the incremental costs to the utility to supply the heat. To supply commercial quantities of moderator heat, a warm water pipeline system between the generating station and customer's equipment would be required. For reasons of site security, Hydro would build and operate all such facilities up to its site boundary. In order that the corporation's electrical customers not bear any of the cost burden for such facilities the full incremental cost to the generating station for capital, operation and maintenance would need to be recovered from the price charged for the warm water.

For any major development of waste heat applications to occur the incremental supply costs to the utility must be attractively less than conventional fuel alternatives. When this happens, it is reasonable to expect that the economic benefit (the difference between utility's incremental supply cost and the cost of a conventionally fuelled heating alternative) will be shared by both the utility and user of the heat. The utilities share will be based on the particular pricing policy it adopts and will generally be one of three alternatives; a) a nominal or token surcharge above its incremental costs for supply, b) a fixed rate of return on the capital outlay for the incremental costs of supply, or c) a negotiated price aimed at charging what the market will bear. For the supply of condenser waste heat to greenhouses on the Sherco site (15), Northern States Power has adopted a pricing policy based on the second alternative, a fixed rate of return on its incremental investment. The rate of return is equivalent to that charged for other services provided by the Company.

In Ontario, although the Power Corporation Act provides for Ontario Hydro to supply power in forms other than electricity, it requires pricing to be based on the cost of supply and

does not provide for normal fixed rates of return other than some contingency charges used from time to time to stabilize rates and protect debt on undepreciated equipment. An effective rate of return could be provided for on any investment the utility might make in waste heat supply facilities by allocating a portion of existing fuelling and capital costs (non-incremental costs) of the generating station to the price payable for waste heat. This would effectively provide the electrical customer with a rate of return for the investment risk of building the warm water supply system. Risks include: possible loss of capital investment should the heat load not continue over the cost recovery period, unaccounted costs for increased administration overheads, developmental engineering costs and possible reduced reliability of electric supply.

One further important perspective must be recognized when discussing utility pricing of waste heat. It is fair to say that utilities have a demonstrated interest in waste heat utilization and have been major contributors to the R and D activities carried out to date. These interests include not only public relations and conservation, but for many utilities, particularly those with increasing nuclear generation capacity, waste heat utilization schemes might be seen as a precedent-making step toward becoming suppliers of higher temperature heat in a future where cogeneration is likely to be an important part of the power business. With this recognized, its unlikely any utility will adopt a pricing policy for waste heat that acts as a deterrent to otherwise economically feasible developments.

Feasibility studies are cheap but do not answer a lot of unknowns. A demonstration project is needed which has to satisfy the interests and objectives of the utility, users, regulatory agencies, the scientific community, public interest groups and the consumers. This is an almost impossible task but it has to be attempted, recognizing that each of these groups will have a say sooner or later. A very small number of the questions that come to mind are:

- Can a family orientated, non-centralized greenhouse industry be changed to a centralized, highly commercial operation, supporting a staff of specialists?
- Will there be consumer resistance to products grown near a nuclear station?
- Is there any responsibility to attempt to change Canadian attitudes towards products produced by intensive culture? For example, cold water species of

fish for the luxury market appears to be the only economical form of aquaculture at present, so should anyone be attempting to increase the public acceptance of a wider range of fish species? To make an aquaculture facility viable it may be necessary to consider growing several species throughout the year. Fish protein is a low priority item in the Canadian diet and there seems to be no national desire to increase fish consumption over meat. It is doubtful if the economics of fish protein production, other than for the luxury market, could be made attractive unless a very cheap fish food were found. It may be a long time before the Canadian consumer would accept fish grown on sewage as a food source, for example.

These problems of integration will most certainly increase with the size and complexity of any facility. There is much to be said therefore in the concept of meeting more localized community needs for commodities produced by low grade heat where there would be a greater incentive to make the project a success.

Low grade heat from sources other than the cooling water from thermal electric generating stations

It is misleading to think of electrical generating stations as the only useful sources of low grade heat. Other industries could provide useful low grade heat for specific uses. For example, since 1974, hot exchange gases from the Saskatchewan Power Corporation's natural gas turbine-operated compressors have been used for an experimental greenhouse operated by the University of Saskatchewan (3). Since then, using the same principle, Alberta Gas has built 0.4 ha of greenhouses at Brooks, Alberta for the hydroponic production of tomatoes and cucumbers (17). Three employee houses, three compressor buildings and the fuel gas heat exchangers are also heated. The contractor grower has had problems unrelated to the heat source, and operation of the greenhouses is temporarily stopped. However, Alberta Gas hopes to resume the project later this year. This operation appears to be the most advanced, and if successful, there is no reason why similar installations could not be built at compressor stations on more northerly points of the pipelines close to Indian and other communities. The pipeline companies now see this use of waste heat as a means for winning approval for its projects in northern communities.

An experimental greenhouse has been set up this year at St. Thomas, Ontario to investigate the feasibility of using the methane gas evolved from closed landfill sites for heating



(18). The 8 ha landfill site is providing about ten times more methane than is required to heat the 6.5 m x 4.5 m greenhouse, which is now growing tomatoes and bedding plants. The methane is expected to be available for twenty years. It is hoped to demonstrate that small greenhouses can be installed and heated by burning waste methane at any large enclosed landfill site.

The Sherco greenhouse project in Minnesota (15) has established that a fairly uniform flow of 30C water is adequate for greenhouse heating in northern climates, so any reliable water supply, at the same or higher temperatures, would be economically attractive. In the food processing industry there are several waste streams in the temperature range 60C to 80C (6). Very high temperature waste streams are presently found also in the pulp and paper, steel, glass, textile and cement industries (5,7). In a four hundred tons per day paper mill, heat from the drying room having a closed hood exhaust would be capable of supplying 60C water from scrubbing towers for about 350 days of the year, 24 hours a day. Even an average sized bakery could provide 175C oven exhaust air streams for about 80 percent of the time. Such streams could exchange with water reservoirs to store heat during periods of plant down time.

Such high temperature streams are attractive for possible use in greenhouse and space heating developments. However, for large aquaculture facilities, the condenser or moderator cooling water flows from an electrical generating station appear to be still the most attractive forms of waste heat because of the large volume available, lack of contamination and the ready availability of cooler water for blending for temperature control.

Waste heat from electric transformers has been utilized in a number of applications in recent years. Although electric losses from transformers are only in the order of 0.15 percent, large transformers can produce useful amounts of heat; as much as 400 kW from a full loaded 250 MVA transformer. The heat is normally rejected to cooling air circulated across oil cooler fins. Applications for this form of waste heat outside Ontario include; a) heating of a substation control house at the Bonneville Power Administration's J.D. Ross substation in Vancouver, Washington using a heat pump system between the transformer and control house (8), b) heating of the service water supply for the Sears tower in Chicago from a Commonwealth Edison substation located within the building, and c) heating of building makeup air at Hydro Quebec's head office.

In heavy water plants in Canada which use the Girdler-Sulfide process, significant amounts of heat are rejected in two separate water flows. One is the process effluent flow (water stripped of D<sub>2</sub>O) which leaves the plant warmed from the process heating. At the Bruce Nuclear Power Development the process effluent flow is approximately 850 l/s at 49C to 72C from each of the heavy water plants. Normally these flows are contaminated somewhat with hydrogen sulfide normally controlled in concentration to less than 1 ppm. The second waste heat stream is the discharged cooling water. At the Bruce Heavy Water Plant B, a unique intake/discharge structure is designed to maintain a constant cooling water inlet temperature to 22C. This will result in a cooling water discharge temperature of about 34C year round. From Plant A cooling water is discharged at approximately 10C above lake water temperature.

### Conclusions

The use of low grade heat from the condenser cooling water of generating stations for heating greenhouses and possibly for other agricultural purposes is neither economically nor thermodynamically attractive in the Canadian climate. However, the higher and more uniform temperature moderator cooling water from CANDU nuclear plants is now being seriously considered for greenhouse heating.

For aquaculture, the condenser or moderator cooling water flows from electrical generating stations appear to be the most readily useable sources of low grade heat. The greatest interest is in production cold water fish species for the luxury market and in this case the supply of adequate cold rather than warm water is the main problem.

Other industries having low grade heat streams generally find that the return on investment required to conserve heat in-plant is too low. If this is the case, uses external to the plant can be considered. Apart from in-plant energy conservation the greatest potential for low grade heat use in Ontario appears to be in the greenhouse production of fresh vegetables out of season. Northern communities particularly, could be saved the high transportation costs of fresh vegetables if low temperature waste heat streams from pulp and paper mills, gas pipelines, or other local industries could be used for greenhouse heating. The provinces of Alberta and Saskatchewan appear to be ahead in recognizing the value of these more northern sources of low grade heat for the benefit of local communities.

A new impetus to low grade heat utilization may result if, instead of asking the question, "how can we use all this low grade heat?" we ask "how can additional benefits be supplied economically and conveniently to a community or area by the use of a particular available source of low grade heat?".

There is a great potential for establishing a greenhouse industry near CANDU nuclear plants. However we should not lose sight of the need for relatively small, isolated communities to make use of low grade heat from nearby industrial sources.

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The Design and Commissioning of the Wastewater  
Treating System at Texaco's Nanticoke Refinery  
by  
R.D. Cameron, Texaco Canada Inc., Nanticoke

### THE REFINERY

In November 1978 Texaco Canada Inc. started up a new 105,000 barrel per operating day petroleum refinery that is located 2 miles from the north shore of Lake Erie 35 miles southwest of Hamilton, Ontario. This integrated refinery is designed to produce leaded and unleaded gasoline, jet fuels, heating oils, diesel and industrial fuels, liquefied propane and butane, and by-product liquid sulphur. The refinery processes crude oil received by Interprovincial Pipeline from western Canada. Approximately 65% of the products are distributed by pipeline throughout eastern Ontario. The remaining 35% of the products are transported throughout the Province by ship, tank car and tank truck.

The major process units are:

- atmospheric and vacuum distillation to separate the crude oil into its components;
- fluid catalytic cracking to convert heavy distillates to lighter components for gasoline and fuel blending;
- catalytic reforming to upgrade low octane naphtha to high octane gasoline streams;
- alkylation to produce additional high octane gasoline components from olefins and butanes; and
- sulphur recovery to convert hydrogen sulphide to elemental sulphur. This unit is a three stage Claus sulphur recovery unit which prevents emissions to the atmosphere of sulphur compounds from fuel gas and sour wastewaters.

### ENVIRONMENTAL PLANNING

In order to fulfill our obligation as a good corporate citizen and welcomed neighbour, Texaco has emphasized protection of the environment from refinery conception through every major design phase of the project. Of the \$480 million cost of the entire complex, over \$70 million was spent directly on environmental protection facilities and millions more on indirect environmental considerations incorporated into the process design.

The 1,480 acre site for the refinery was selected to minimize any possible impact upon the environment. The site is within an area zoned for heavy industry, adjacent to a light industrial zone; all of which is located within a three kilometer wide industrial influence area between the industrial and future residential sectors.

Following site selection, Texaco cooperated with the Ontario Ministries of the Environment and of Natural Resources, and our new neighbours - Ontario Hydro and Stelco - to finance intensive pre-operational studies of the surrounding environment. The Nanticoke Environmental Committee was established with the objective to investigate the effect of the industrial development upon the aquatic environment of Long Point Bay. Another project, the Nanticoke Environmental Management Program was started to study the ambient air quality in the area aided by a network of over 30 monitoring stations. These studies have now entered the post-Texaco startup phase of investigation and are designed to evaluate the impact of each of the local heavy industries upon the air, land and water environments.

Texaco also took immediate steps to minimize the effects of construction and operations on local neighbours by establishing a buffer zone within the refinery's perimeter. Not only are the process units set back from the boundaries, but the visual impact of the installation will be screened from the roads and neighbouring properties by existing trees, which are augmented by 42,000 additional plantings.

An outstanding feature of Nanticoke Plant's environmental protection program is the incorporation of an environmentally sound philosophy into the design of the refinery. The first step in realizing our goals, was the delineation of an Environmental Protection Philosophy for water usage and its subsequent treatment, i.e.:

- MINIMIZE WATER USE
- MAXIMIZE GOOD HOUSEKEEPING
- MAXIMIZE SOURCE TREATMENT
- MAXIMIZE SEGREGATION OF WASTE STREAMS
- MAXIMIZE TREATMENT UNIT EFFICIENCIES
- MAXIMIZE OPERATOR TRAINING PROGRAMS.

The adoption of this philosophy was necessitated by three concerns:

- the effect of the effluent from Nanticoke Plant which is discharged into Lake Erie's Long Point Bay. Long Point Bay is an important natural environment which supports such activities as one of the two North American yellow perch hatcheries, the largest inland commercial fishery on this continent and both mid-continental flyways for some 350 species of birds;
- the commitment by the Company to meet all the applicable environmental protection regulations, guidelines and requirements for operating permits;
- the economics of achieving the desired treatment. As each gallon of water treated represents a capital and operating cost, minimizing the amount of effluent to be treated served to reduce the size and hence the cost of the wastewater treatment units required.

#### MINIMIZE WATER USE

The prime methods used to reduce water use are, where possible, replacing cooling water with air and the multiple use of water.

#### Reduced Cooling Water Use

One of the major uses of water in a petroleum refinery is as a cooling medium. If cooling water had been used in Nanticoke Plant on a "once-through" basis, 50,000 to 60,000 gallons per minute of warm water would have been discharged to the lake after a single pass through product coolers. As a result of our efforts Nanticoke Plant discharges approximately 1/50 of this amount of water.

Nanticoke Plant has substituted air in the place of water for 85% of the refinery's cooling requirements. This decision led to the installation of 45,000 square feet ( $4,200\text{m}^2$ ) of air fan coolers. The capital cost of air fan coolers is greater than water coolers for two main reasons; larger heat transfer surfaces are needed and special precautions are required to reduce noise generation. An additional cost of over \$2 million was accepted to install low noise, slow speed fans.

Supplementary water cooling for the remaining 15% of the refinery cooling requirements is supplied by 30,000 gpm ( $2\text{ m}^3/\text{s}$ ) of circulating cooling water. Using treated raw water as makeup to the system to minimize scale formation allows the water to be recycled a maximum number of times through the system. A 4-cell cooling tower is the radiator section of the cooling system, wherein the cross-flow heat exchange and evaporation lowers the water medium temperature to allow further process cooling.

The use of air fans and cooling towers reduces the refinery's cooling water use to 120 gpm ( $650\text{ m}^3/\text{d}$ ) at 5 cooling water cycles, or 85 gpm ( $460\text{ m}^3/\text{d}$ ) at 10 cycles.

#### Multiple Water Usage

Raw water usage is also minimized by re-use of process waters. Waters are collected for either re-use in the same process, or in another process.

By its nature, the quality of condensed steam is as good as the boiler feed water used to produce it. When practical, in locations where there is at least 10 gpm ( $50\text{ m}^3/\text{d}$ ) of condensate, it is collected and recycled to the Boiler Feed Water Plant.

Matching the quality of one type of wastewater with the water quality of that required in other processes allows water to be re-used. One of many applications of this re-use is the recycling of condensate from the vacuum distillation tower to the crude oil electrostatic desalters (reference Figure 1). This particular application reduces refinery water use by approximately 200 gpm ( $1100\text{ m}^3/\text{d}$ ).

## Water Recycling

To minimize fresh water consumption, refinery effluent water is recycled for selected purposes within the plant. Service water is drawn from the Wastewater Treatment Plant's (WWTP) Recycle Ponds to supply utility water for process area washings and in some cases it is used as process water makeup. The prime source of refinery fire fighting water is also from this source where 4 million gallons (15,000 m<sup>3</sup>) of water is stored for this purpose.

## MAXIMIZE GOOD HOUSEKEEPING PRACTICES

The concept of good housekeeping is based upon the principle that if waste materials are controlled at the source, then one does not have the less efficient and more expensive task of removing them from the effluent.

Some illustrations are:

- closed loop sampling to prevent hydrocarbon wastage during the taking of samples;
- the use of vacuum trucks to withdraw storage tank water bottoms rather than draining the water onto the ground;
- the use of drains connected to the contaminated water sewer for those tanks that are drained more frequently;
- the pumping or vacuuming dry of hydrocarbon lines before they are disconnected or dismantled;
- the use of drip pans under flanges before they are disconnected to insert blinds, etc.

By these means it is intended to prevent soil and water contamination and the creation of unsightly areas.

In addition to having proper equipment available and paying careful attention to correct operating procedures, an effective housekeeping program requires an understanding of individual responsibility on the part of every employee to prevent accidental environmental incidents.

## MAXIMIZE SOURCE TREATMENT

In some situations it is more efficient to treat specific wastewaters at their source, rather than at the Wastewater Treatment Plant where they have been diluted by cleaner waters. Examples would be ammonia removal from sour waters, and the neutralization of spent caustic.

### Sour Water Stripping

The Nanticoke Refinery has two major sources of waters containing hydrogen sulphide ( $H_2S$ ) and ammonia ( $NH_3$ ). These are FCCU sour condensates at a flow of 110 gpm ( $600\ m^3/d$ ) and desalter water at a flow of 210 gpm ( $1100\ m^3/d$ ). In designing the sour water stripping system several process modifications were adopted to achieve the calculated tower outlet requirements of  $1\ mg/\ell\ H_2S$  and  $5\ mg/\ell\ NH_3$ . These limits, coupled with the low water use in the refinery, determined that all streams containing these contaminants had to be collected and steam stripped before being treated further in the biological oxidation unit and subsequently discharged to the lake.

The most significant processing principle incorporated into the sour water system design is the stripping of desalter water. In other refineries desalter water may not contain appreciable amounts of sulphide or ammonia; however, at Nanticoke, the type of crude oil refined requires heavy ammonia injection for corrosion control in the Vacuum Unit. This water is re-used in the desalters causing a high ammonia concentration in the discharged water, hence stripping is required.

Another variation in the design was that the FCCU sour condensate and CSU desalter water had to be stripped in separate towers. Experience indicates that when highly saline waters are mixed with soft condensate waters and steam stripped, the salt tends to plate out in the towers. This same phenomenon is not as pronounced when the streams are stripped separately.



The design of the stripping towers incorporates three significant features (reference Figure 2) which are; 44 stripping trays, steam reboiling and pumped/air cooled top reflux. Conventional designs called for 10 to 30 stripping trays; however, it was determined that 44 trays and up to 1.5 pounds of steam per gallon of water treated are required for this high efficiency operation. The steam reboiler provides for recovering the steam and recycling it as clean condensate. Had direct steam stripping been used, it would have contributed to increased wastewater flow. The pumped/air cooled top reflux concept was borrowed from refinery tower top process design, and greatly improves the efficiency and thus the entire sour water stripping design.

The effect of our process design modifications is reflected in the operating data from these towers. As evident from Table 1 for the FCCU Sour Water Stripper, the design is more than capable of meeting the performance criteria.

TABLE 1  
**44-TRAY FCCU/CRU  
SOUR WATER STRIPPING TOWER**

| <u>Actual Operation vs Design</u> |                 |                 |                   |                 |
|-----------------------------------|-----------------|-----------------|-------------------|-----------------|
|                                   | <u>Actual</u>   |                 | <u>Design</u>     |                 |
| Flow (gpm)                        | 105             |                 | 110               |                 |
| Total Steam (lb/gal)              | 1.5             |                 | 1.5               |                 |
|                                   | <u>Influent</u> | <u>Effluent</u> | <u>Efficiency</u> | <u>Effluent</u> |
| Sulphides (ppm)                   | 990             | 0.2             | 99.98%            | 1 ppm           |
| Ammonia (ppm)                     | 1900            | 3.5             | 99.8%             | 5 ppm           |
| pH                                |                 | 9.3             |                   | -               |

#### Spent Caustic Neutralization

A second prominent example of source treatment is the neutralization of spent caustics before they enter the sewer system for further treatment in the biological oxidation unit. Treating these materials at the source prevents the formation of emulsions and oil entrainment in the wastewaters.

At many refineries, neutralization is accomplished using mineral acids; however, Nanticoke Plant uses FCCU waste flue gas that contains carbon dioxide as the neutralizing agent. One of the benefits of using this process is that the waste gases from the neutralizer containing hydrocarbon and hydrogen sulphide can be incinerated directly, minimizing air and water environmental problems.

One of the outstanding process design features of the Nanticoke Plant spent caustic neutralization system is (reference Figure 3) the use of a vertical contacting tower and the countercurrent flow of caustic and flue gas. This process design is more efficient in neutralizing caustic and stripping hydrogen sulphide than the horizontal static type where the flue gas is bubbled through the caustic.

Also incorporated into this system is an entrained mist disengaging drum and several spent and neutralized caustic storage tanks to provide operating flexibility and the equalizing of the flow of neutralized caustic to the Wastewater Treatment Plant.

#### MAXIMIZE SEGREGATION OF WASTE STREAMS

This philosophy was incorporated into the design of the Nanticoke Wastewater Treatment Plant to minimize the size of the treatment facilities while providing selective treatment for those streams requiring it. The waste streams that have been segregated are process waste waters, ballast water, clean storm waters, sanitary wastes, cooling tower blowdown and other high dissolved solids containing streams, oil wastes, sour waters and spent caustics. This philosophy resulted in the refinery being designed with four major sewer systems, as well as four subcollection systems.

#### Contaminated Water Sewer

The Contaminated Water Sewer collects all process waters that come into direct contact with hydrocarbons. Included are the Sour Water Stripper and Spent Caustic Neutralizer effluents, miscellaneous process waters, and those storm and pad wash waters that have a potential of being contaminated. This sewer extends from the northern marketing and tank field areas to the Wastewater Treatment Plant.

### (Clean) Storm Water Sewer

Storm waters from the 125 acres of developed property, excluding the Process Units which are treated as contaminated areas, are collected by the Refinery's largest system - the (Clean) Storm Water Sewer.

Two techniques have been used to reduce the size of the facilities to handle storm waters and the volume of waters for which the Refinery is accountable. The first is the use of periphery ditch/dykes to route clean surface waters from non-developed refinery areas away from developed areas. Non-developed area waters are diverted to natural drainage courses.

The second technique is to control run-off from the developed areas to minimize the volumes that have to be handled during a storm. An extensive system of control gates and open ditches within the dyked tank fields allows run-off from these areas to be retained and released in a controlled manner when downstream treatment capacity is available. Water contained in each tank field is inspected to determine if it is clean or contaminated before being released to either the Storm or the Contaminated Water Sewer.

### Sanitary Sewer

All sanitary wastes and sometimes boiler blowdown are collected and conveyed in a segregated sewer and a series of lift stations directly to the Biological Oxidation Unit. The boiler blowdown is included in this sewer when heat or phosphates are required in the Biological Oxidation Unit.

### High Dissolved Solids Sewer

The High Dissolved Solids Sewer collects those wastewater streams which contain only neutral dissolved solids and do not require treatment. The sources of high dissolved solids material are neutralized demineralizer regeneration waters from the Boiler Feed Water Treatment Plant, clean Cooling Tower and Boiler blowdowns.

### Oil Sewer

The oil subcollection system is intended to segregate oil drainings and leaks from pumps and other process equipment. The oil in the sumps is either picked-up by vacuum truck or pumped on level control to slop oil tankage for reprocessing.

### Sour Water Sewer

Sour waters are collected by two above ground closed piping systems - one for the FCCU Sour Water Stripper, and another for the Desalter Sour Water Stripper. Each system has a storage tank with 7 days' capacity to contain flows during a stripper shutdown. A common caustic scrubber on the tank vents absorbs hydrogen sulphide that could be released to the atmosphere from the holding tanks.

### Spent Caustic Collection System

Processes which use caustic are supplied with a Spent Caustic Collection System for transferring this material to one of three holding tanks for storage prior to being neutralized.

### Ballast Water System

Ballast water from ships is transferred by a two and a half mile (4 km) pipeline to a 45,000 barrel (7150 m<sup>3</sup>) Ballast Water Holding Tank. Following 24 hours of settling, the water is drained in a controlled manner to the Contaminated Water Sewer for subsequent treatment. A number of concepts have been designed into the Ballast Water Holding Tank (reference Figure 4):

- a slotted inlet line across the diameter of the tank to minimize the emulsification of any oil phase in the tank due to the high velocity of the influent flow;
- a high level overflow that drains from the bottom of the tank and allows the settled water to overflow, rather than the floating oil layer. This overflow line is also equipped with a syphon breaker to prevent the contents of the tank from being drawn down;

- two liquid level indicators have been provided - one with a low density float to indicate the total innage; and the other with a high density float to indicate the oil/water interface. The tank is also equipped with a high level alarm to warn of a potential overflow;
- a perforated discharge line across the tank bottom prevents the vortexing of separated oil during the draining of water. The drain line also includes a vertical loop equipped with a syphon breaker to allow unattended draw down to a present level without discharging any of the oil phase.

#### MAXIMIZE TREATMENT UNIT EFFICIENCIES

The major constituent of Nanticoke Plant's environmental philosophy is to maximize the efficiency of treating the contaminated wastewaters. All of the associated equipment was installed to maximize the efficiency of the "end of pipe" wastewater treatment units. The philosophical guidelines that were incorporated into the conceptual design of the Wastewater Treatment Plant are:

- gravity flow of water from unit in order to minimize pumping requirements;
- dual or triple treatment trains to allow for maintenance shutdowns;
- each train is sized to allow the continued treatment of the "dry weather" flow;
- use of conventional proven technology, modified as necessary to provide an integrated balanced treating system;
- custom design of units using in-house process specifications.

Texaco's intent to maximize efficiency of treating wastewaters resulted in a Wastewater Treatment Plant that is described as follows (reference Figure 5).

### Primary Diversion

The wastewater treating units are designed for an average "dry weather" flow of 1000 gpm (5500 m<sup>3</sup>/d) and a maximum capacity of 1500 gpm (8200 m<sup>3</sup>/d). However, with the inclusion in the Contaminated Water Sewer of surface run-off from refinery process area pads there could be a flow to the Wastewater Treatment Plant of over 18,000 gpm (1.1 m<sup>3</sup>/s). This necessitated some form of flow diversion. To accomplish this, the forebay of the standard oil/water gravity separator was modified with the use of weirs and water heads (reference Figure 6) to allow in the order of 1500 gpm to carry through to treatment with the excess being diverted to the 4 million gallon (15,000 m<sup>3</sup>) Contaminated Water Surge Pond. Oil-retaining baffles in the inlet cause an underflow/overflow of diverted waters and the usual oil skimming and sludge scraping ancillary equipment is installed in the forebay.

### Primary Oil Separation

The design of the Contaminated Water Separator is based on the standard American Petroleum Institute criteria for gravity separation of fine oil particles in rectangular channels. It was decided to use different skimming/scraping methods in the forebay and main channels of the Separator. In the forebays the standard chain-and-Flyte skimmers and scrapers were used since they are well suited to the short bays and high oil recovery rates. This type of skimmer installation also allowed the forebay, where most of the oil is trapped, to be covered.

In the main channels of the Separator a "travelling bridge" was used since it was considered to be more mechanically reliable than Flyte scrapers when used to traverse the long length of these channels. The theory is that there is much less stress on the travelling bridge system than there is on a chain that is driven from a sprocket 100 feet (30.5 m) away.

To provide the most efficient operation, programmed timers are used to set the frequency and duration of the oil skimming, sludge scraping, and sludge withdrawal operations.

### Secondary Diversion

Secondary diversion capability was incorporated into the Separator's effluent channel to overcome flow variations not accounted for in the design and the difficulty in setting 140 feet (42.7 m) of weir at a precise elevation. The use of this secondary diversion weir allows the automatic fine tuning of the flow down to 1500 gpm (8200 m<sup>3</sup>/d) in order not to upset the downstream units which are more sensitive to flow variation. Shutdown valves also allow the operator to divert some or all of this flow to the Contaminated Water Surge Pond.

### Automatic pH Control

The Secondary Diversion Channel being the entrance to the Equalization Tanks, is the point of injection of pH-controlling acid and caustic. Continuous in-line pH monitors forewarn of unacceptable pH levels in the Contaminated Water Separator effluent, whereupon the operator may activate the automatic pH controllers. With set points to effect a pH range of 8.0 - 8.5 in the biological treatment unit, acid or caustic is injected at a rate proportional to the wastewater flow and the pH divergence from the desired range.

### Quality Equalization

Two parallel Equalization Tanks were installed to provide chemical equalization. These tanks are equipped with slow speed mixers. The combined retention time is 6 hours at the design flow. These tanks dampen short term quality fluctuations to downstream systems, allow time for buffering of pH fluctuations and the reaction of injected pH-controlling acid or caustic.

Effluent from these tanks is monitored for flow and pH level to control the injection of chemicals to adjust pH and improve intermediate oil separation.



### Intermediate Oil Separation

A Dissolved Air Flotation (DAF) design was chosen as the intermediate oil separation treatment unit. Based upon Texaco's criteria, a three stage unit was designed to include a 50% effluent recycle flow. The stages of the unit are Rapid Mixing, Flocculation and Clarification which are described as follows:

- a) The Rapid Mix Tanks have a hydraulic residence time of one minute. The coagulating and flocculating chemicals are separately introduced for uniform dispersion by high speed mixers, which provide mixing at a rate of 1 HP per thousand gallons of volume.
- b) The Flocculation Tanks are designed to allow floc growth and particulate entrapment to occur. These vessels have a hydraulic residence time of 15 minutes and use slow speed paddle wheels sized to provide mixing based on 0.15 HP per thousand gallons of volume.
- c) Clarification of the floc from the wastewater is effected in the Flotation Tanks. The recycled effluent is super-saturated with compressed air pressurization tanks. The discharge of the recycle through bottom diffusers in the Flotation Tanks causes the generation of discrete micro-bubbles. These exert a buoyant force to float the floc to the surface. These tanks are conservatively sized for a hydraulic residence time of 50 minutes and a surface loading of 1 gpm/sq. ft. ( $60 \text{ m}^3/\text{m}^2.\text{d}$ ), which produces an effluent low in oils and suspended solids.

### Automatic Temperature Control

The DAF effluent channel is the location where low pressure steam is injected. A thermocouple in the inlet sump to the Biological Oxidation Unit (BOU) automatically controls the steam injection to warm the  $60^\circ - 70^\circ\text{F}$  ( $15^\circ - 20^\circ\text{C}$ ) wastewater to a temperature of about  $90^\circ\text{F}$  ( $32^\circ\text{C}$ ) in the BOU. A second set of thermocouples in the effluent channel of the Aeration Basins indicates the operating temperatures.



## Secondary Treatment

The Biological Oxidation Unit is considered to be the heart of the Wastewater Treatment Plant. When it is operating well the plant effluent meets the discharge criteria; whereas a malfunctioning unit causes unacceptable effluent quality. (Reference Figure 7).

Secondary treatment consists of a completely mixed activated sludge unit having 12 hours hydraulic residence time. Two-speed mechanical surface aerators, are sized to mix at a rate of 1 HP per thousand cubic feet of volume and transfer 2 pounds of oxygen per break horsepower per hour. These mixers are operated to provide a minimum dissolved oxygen content of 2 mg/l. Three aerators per basin allow operating flexibility to balance power consumption while still effecting proper aeration.

Segregated sanitary sewage and nutrient phosphoric acid are routed into the inlet sump of the Aeration Basin. The sanitary sewage, by its nature, requires secondary treatment, but does not require primary and intermediate oil separation and therefore bypasses these processes. Optionally, blowdown from the Refinery's steam boilers is included as a phosphate source for the bio-culture supplemented by phosphoric acid additions as needed.

The activated sludge unit operating parameters are:

### BOU Influent Quality

|        |            |
|--------|------------|
| Oils   | < 5 mg/l   |
| Solids | < 10 mg/l  |
| Phenol | 10-30 mg/l |

### Aeration Basin Operating Criteria:

|                          |                                       |
|--------------------------|---------------------------------------|
| pH                       | 7.5-9.0                               |
| Temperature              | 85°-90°F                              |
| Dissolved Oxygen         | 2 mg/l                                |
| Solids                   | 6000 mg/l total<br>3600 mg/l volatile |
| Sludge Age               | 65-75 days                            |
| Hydraulic Residence Time | 10-13 hours                           |
| Clarifier Sludge Recycle | 50%                                   |

Maintaining these operating parameters results in a BOU effluent phenol content of consistently less than 20 µg/l.

An indication of the stability of the secondary treatment process is that the unit, which started up with 8000 gallons ( $36.5 \text{ m}^3$ ) of sanitary sewage "seed" culture in 1.1 million gallons ( $4560 \text{ m}^3$ ) of Aeration Basin volume, prior to the Refinery commissioning, has not had a serious upset during its first year of operation.

### Secondary Clarification

Following the Aeration Basins are two parallel Secondary Clarifiers. These are designed for an overflow rate of 450 gpd/sq. ft. ( $20 \text{ m}^3/\text{m}^2.\text{d}$ ). At normal flow, one Clarifier is able to operate effectively, while the other is shut down for maintenance. The effluent from the Clarifiers maintains the volume of the 3 Recycle Ponds.

### Effluent Filtration

Recycle Pond water in excess of the Refinery service water and fire water system requirements is charged to the three parallel Effluent Filters. This final polishing is an assurance that effluent solids content is held to a minimum to protect the receiving lake water. Filtration protects against possible carry over of sludge solids from the Secondary Clarifiers. Furthermore it was felt that the 3-4 days hydraulic residence time of the warm water in the Recycle Ponds, seeded by the BOU, could lead to algal blooms which may affect the Wastewater Treatment Plant effluent quality.

The Filters (reference Figure 8) are of the downflow, pressure, dual media type; with 3 feet (0.9 m) anthracite coal and 1 foot (0.3 m) silica sand beds. Backwashes are program-controlled once they are manually activated by the operator. Effluent quality from the Filters after the first year of operation has been very good, primarily due to:

- pre-start-up engineering review and equipment modification;
- care spent during media loading and pre-operational cleaning;
- below design charge rates due to the recycling of biologically treated wastewaters to the Refinery;
- minimal suspended solids Filter loading;
- commitment to Filter backwashing once per day, whether the Filter is fully loaded or not, in order to maintain non-septic Filter beds.

#### Final Holding Ponds

Effluent from the Filters is discharged into the High Dissolved Solids Sewer and routed to two Final Holding Ponds. The Ponds allow 12-hour retention of the Wastewater Treatment Plant effluent for final monitoring. Operated on either a batch fill/empty mode, or in a continuous flow-through manner, routine operator monitoring and 24-hour automatic composite sampling at 15-minute intervals allows for the retreatment of off-specification waters. If only suspended solids concentrations are unacceptable, the final waters can be rerouted through the Effluent Filters. Other unacceptable contaminant levels result in recycling for complete retreatment.

#### Sludge Handling

Initial treatment facilities for wastewater treatment sludges have been installed. Primary oil separator bottom sludges and, optionally intermediate oil separation froths, are routed to an elevated Gravity Sludge Thickener. Gentle stirring by internal pickets prevents the sludges from "cementing up" during the gravity thickening process. Thickened sludge is unloaded from the bottom of the thickener directly into disposal vehicles.

Wasted biological sludges are aerobically digested in a covered below ground Digester. Slow speed turbine mixing with air and steam injection effects digestion during a 20-day sludge retention time. Digested sludge is transferred to a Sludge Holding Tank where a 160-day capacity allows sludge storage during periods unfavourable for sludge disposal.

Ultimate sludge disposal is presently under review by our engineering staff and a soil biodegradation area, as well as other alternate methods of disposal are being considered.

#### Segregated Clean Storm Waters

Texaco's extensive property at Nanticoke Plant results in the necessity to control significantly large clean storm water run-off volumes in the order of 90 cfs (2.5 m<sup>3</sup>/s). The Refinery layout allows for segregation of clean areas to prevent oil contamination of storm water in ways that are not always possible in older refineries.

Although designated as clean developed areas, the presence of hydrocarbon transfer pipelines and roadways do present a potential for contamination. In an attempt to contain spills and recover readily separable oils that could be present in storm waters, a Guard Separator was designed at 1/2 the hydraulic flow design criteria normally used by the American Petroleum Institute for process waters. The result was a separator which is equipped with modified surface oil skimmers, diversion entrance baffles and effluent channels in response to the Texaco hydraulic criteria.

To take into account any road oil picked up by light drizzle, 1000 gpm of guard separator effluent can be automatically diverted to the contaminated water handling system. Subsequent retention of the treated clean storm waters in the Storm Water Holding Pond for testing allows for its controlled discharge through an energy dissipator to a local creek, or to full Wastewater Treatment Plant treatment as a contaminated water.

## MAXIMIZE OPERATOR TRAINING PROGRAMS

Realizing that the effectiveness of the most modern facilities can be greatly reduced by untrained operators, the position of Wastewater Treatment Plant Operator was incorporated into the Refinery's training program.

Briefly, Nanticoke Plant has adopted a program of "participatory management". Under this philosophy:

- the emphasis of this approach is upon team work, upon employee involvement in matters that affect employees and upon the idea that all members of the team share responsibility;
- post-hiring and on-the-job training are programmed and scheduled during paid working hours;
- operators "rotate" to new positions in 15-month cycles;
- practical experience in, and examination upon the content of a new position, are justification for promotion to the next level of responsibility.

The training program for the Wastewater Treatment Plant Operator, following the three month post-hiring general refinery training, consists of:

- a one week long classroom course on wastewater treatment, which includes fundamentals as well as specific application to Nanticoke Refinery;
- a 350-page manual issued to each Wastewater Treatment Plant trainee and operator which describes the theory of each treatment unit, mechanical equipment, associated control instrumentation and the operator's responsibility for unit control and monitoring;
- three training days during each 5-week duty schedule which allow the trainee to become familiar with, and then operate the Wastewater Treatment Plant under the supervision of an experienced operator.

Only one Wastewater Treatment Plant operator is required per shift. Although the facilities are comprehensive in nature, this is possible due to:

- an excellent operator training program;
- the use of programmers and/or timers for time consuming, but simple operations such as Primary Separator oil and sludge removal and Filter backwashing;
- the use of automatically controlled injection of treatment chemicals;
- the centralization of operation alarms and injection facilities at the Wastewater Treatment Plant control building;
- the Wastewater Treatment Plant laboratory which allows the operator to analyze the WWTP operations without the delay of submitting samples to the Refinery Quality Control Laboratory;
- a monitoring/analysis shift schedule which concentrates the operator's attention to critical operations, with less intense review of others;
- a Total Oxygen Demand (TOD) analyzer which allows a quick and comprehensive monitoring of the wastewater quality through the plant. With a three minute cycle period, the analyzer catalytically oxidizes a sample and records the oxygen depletion. Routine monitoring of other control parameters augments the TOD analysis.

#### AMMONIA ANOMALY

Worthy of special mention is the anomaly of high ammonia levels in the Refinery effluent. Upon commissioning the process units, the ammonia content of the Wastewater Treatment Plant effluent exceeded the discharge criteria. A value near 100 mg/ℓ was observed. The operation of the WWTP Biological Oxidation Unit was then controlled so as to effect a high sludge age. Over a two month period the extended aeration mode of operation allowed a nitrifying bacteria colony to be established in the BOU. Under stable operation, this colony is able to produce effluent ammonia levels of less than 0.5 mg/ℓ.

However, the nitrifying operation is very "fragile". Unusual pH, phenol, solids, bulking oils, ammonia, or temperature fluctuation to the secondary treatment process, reduce nitrification even though other contaminant removals are not noticeably affected. Figure 9 indicates such a shock, and the 10-11 day period required to recover to the pre-shock level of operation.

The source of the unanticipated ammonia is the Desalter Sour Water Stripper which has consistently been unable to reduce ammonia concentration in the effluent to design levels. Although tower efficiency is affected by oil carryover from the refining processes and by the steam rate to the tower, Figure 10 indicates the relationship between effluent ammonia concentration and pH levels based upon actual analysis of samples taken at the Sour Water Strippers. Refinery engineers are presently effecting pH control of the desalter waters to raise the Sour Water Stripper feed pH level to 8.5 to 9.0.

#### EFFLUENT QUALITY

The proof of Texaco's environmental protection philosophy is the exceptional quality of the discharged effluent resulting from its implementation. Table 2 compares the gross, or total, effluent control contaminant concentrations with the Ontario effluent quality criteria for petroleum refineries. Of interest is Table 3 which takes into account the quality of the water received by the Refinery in determining the "net concentration".

TABLE 2  
**REFINERY EFFLUENT QUALITY  
VS  
ONTARIO EFFLUENT QUALITY OBJECTIVES\***  
(January-February 1979)  
**BASIS GROSS LOADINGS**

| Parameter          |              | Actual<br>Average (range) | Objective |
|--------------------|--------------|---------------------------|-----------|
| Phenols            | ( $\mu$ g/L) | 9 (1-21)                  | 20        |
| Ammonia - Nitrogen | (mg/L)       | 1.2 (0.1-9.8)             | 10        |
| Oils & Grease      | (mg/L)       | 3 (0.3-13)                | 10        |
| Suspended Solids   | (mg/L)       | 2.9 (0.1-15)              | 15        |
| Sulphides          | (mg/L)       | 0 (0-0.2)                 | -         |
| pH                 | (mg/L)       | (5.8-9.0)                 | (5.5-9.5) |

\*\*\*Liquid Effluent Guidelines for the Petroleum Refining Industry"

TABLE 3  
**REFINERY EFFLUENT QUALITY  
 VS  
 ONTARIO EFFLUENT QUALITY OBJECTIVES\***  
 (January-February 1979)  
**BASIS NET LOADINGS**

| Parameter          |        | Actual<br>Average (range) | Objective |
|--------------------|--------|---------------------------|-----------|
| Phenols            | (µg/L) | 8 (0-19)                  | 20        |
| Ammonia - Nitrogen | (mg/L) | 1.4 (0-10)                | 10        |
| Oils & Grease      | (mg/L) | 1 (0-8)                   | 10        |
| Suspended Solids   | (mg/L) | 0.8 (0-11)                | 15        |
| Sulphides          | (mg/L) | 0 (0-0.1)                 | —         |
| pH                 | (mg/L) | (5.8-9.0)                 | (5.5-9.5) |

\**"Liquid Effluent Guidelines for the Petroleum Refining Industry"*

Nanticoke Refinery effluent quality is also controlled by Environment Canada's regulations for "new refineries" which limits discharge loadings in pounds of contaminant per unit production. Tables 4 and 5 compare actual discharge loadings on gross and net bases and show that effluent limits are well within the allowables.

TABLE 4  
**REFINERY EFFLUENT QUALITY  
 VS  
 FEDERAL MAXIMUM ALLOWABLE DEPOSITS\***  
 (January-February 1979)  
**BASIS GROSS LOADINGS**

| Parameter          | Actual<br>Average (range) | Maximum Allowable<br>Monthly Average |
|--------------------|---------------------------|--------------------------------------|
| POUNDS / DAY       |                           |                                      |
| Phenols            | 0.2 (0-1.2)               | 24                                   |
| Ammonia - Nitrogen | 25 (0-220)                | 290                                  |
| Oils & Grease      | 50 (0-200)                | 240                                  |
| Suspended Solids   | 48 (2-200)                | 570                                  |
| Sulphides          | 0.4 (0-2)                 | 8                                    |
| pH                 | (5.8-9.0)                 | (6.0-9.5)                            |

\**Environment Canada's "Petroleum Refinery Liquid Effluent Regulations"*



TABLE 5  
**REFINERY EFFLUENT QUALITY  
 VS  
 FEDERAL MAXIMUM ALLOWABLE DEPOSITS\***  
 (January-February 1979)  
**BASIS NET LOADINGS**

| Parameter          | Actual<br>Average (range) | Maximum Allowable<br>Monthly Average<br>POUNDS/DAY |
|--------------------|---------------------------|----------------------------------------------------|
| Phenols            | 0.1 (0-0.3)               | 24                                                 |
| Ammonia - Nitrogen | 24 (0-220)                | 290                                                |
| Oils & Grease      | 16 (0-120)                | 240                                                |
| Suspended Solids   | 13 (0-148)                | 570                                                |
| Sulphides          | 0.3 (0-2)                 | 8                                                  |
| pH                 | (5.8-9.0)                 | (6.0-9.5)                                          |

*\*Environment Canada's "Petroleum Refinery Liquid Effluent Regulations"*

SUMMARY

In summary, it is concluded from the analyses effected to date, that the application of Texaco's environmental protection philosophy to the Nanticoke grassroots petroleum refinery has resulted in achieving the goals of operating an environmentally sound refinery, and of fulfilling the obligations of being a good corporate citizen and welcomed neighbour.

FIGURE 1

## CASCADING DISTILLATION TOWERS' CONDENSATES

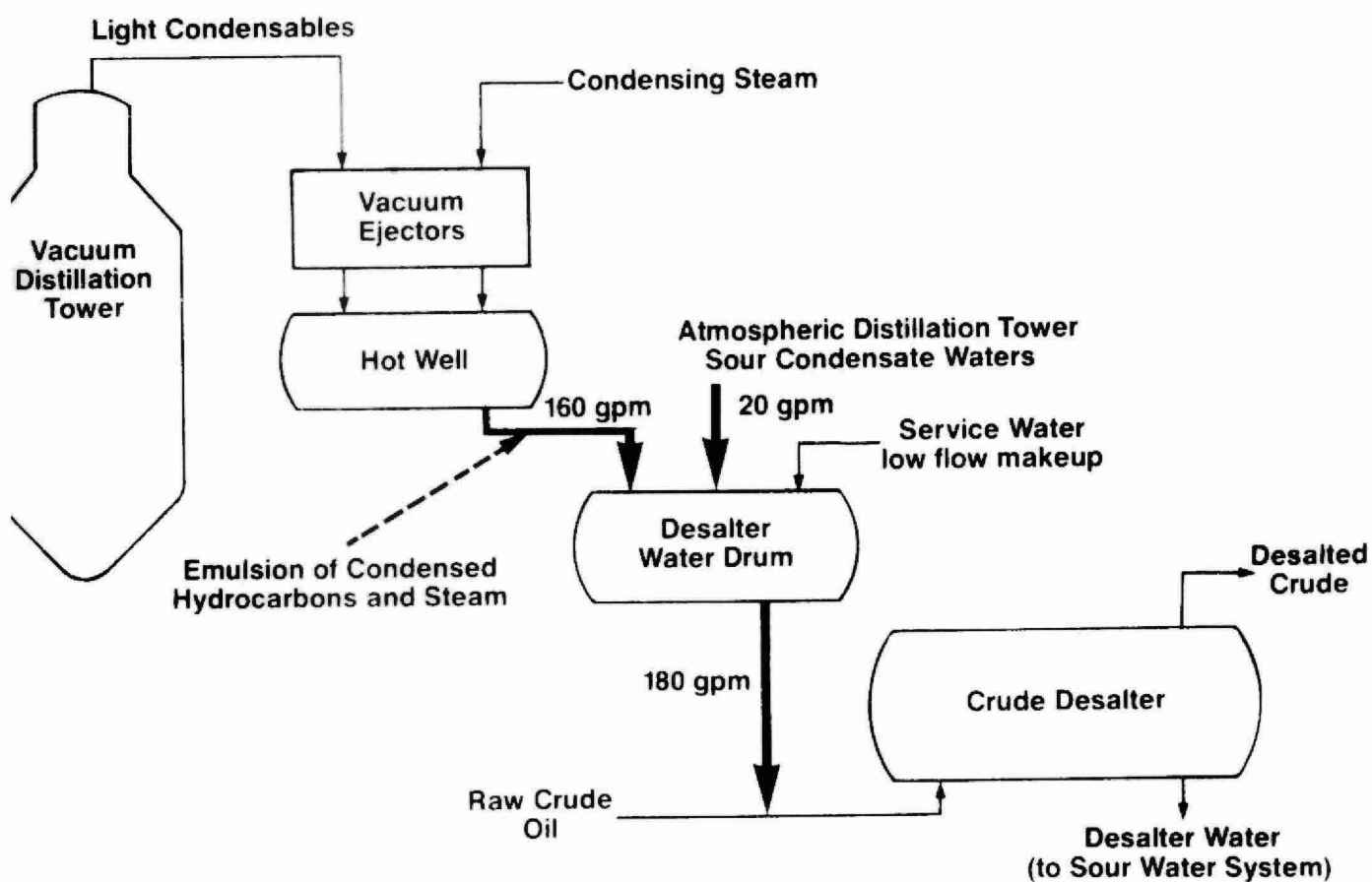


FIGURE 2

**SOUR WATER STRIPPER  
WITH STEAM REBOILING AND PUMPAROUND REFLUX**

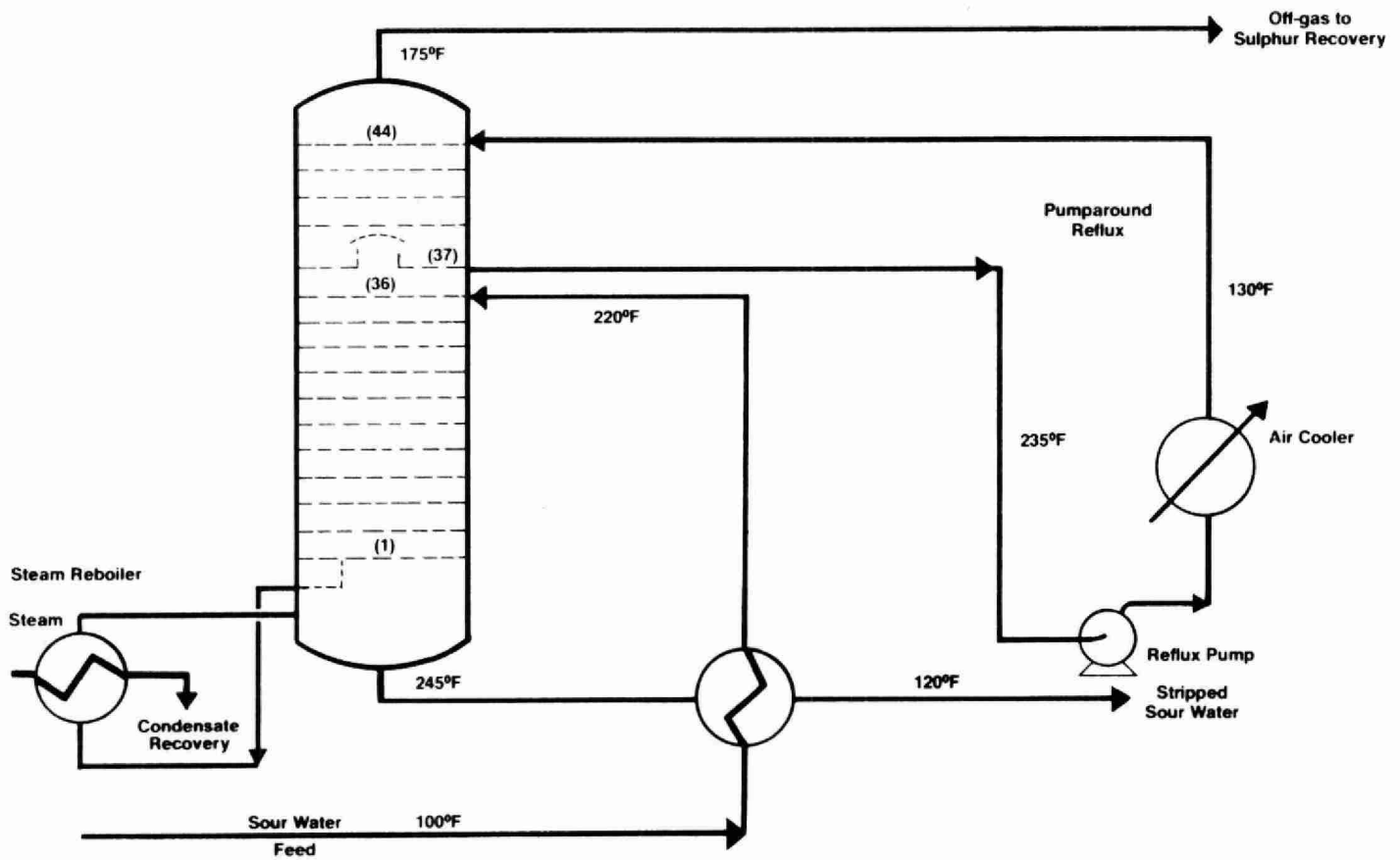


FIGURE 3

### SPENT CAUSTIC NEUTRALIZATION

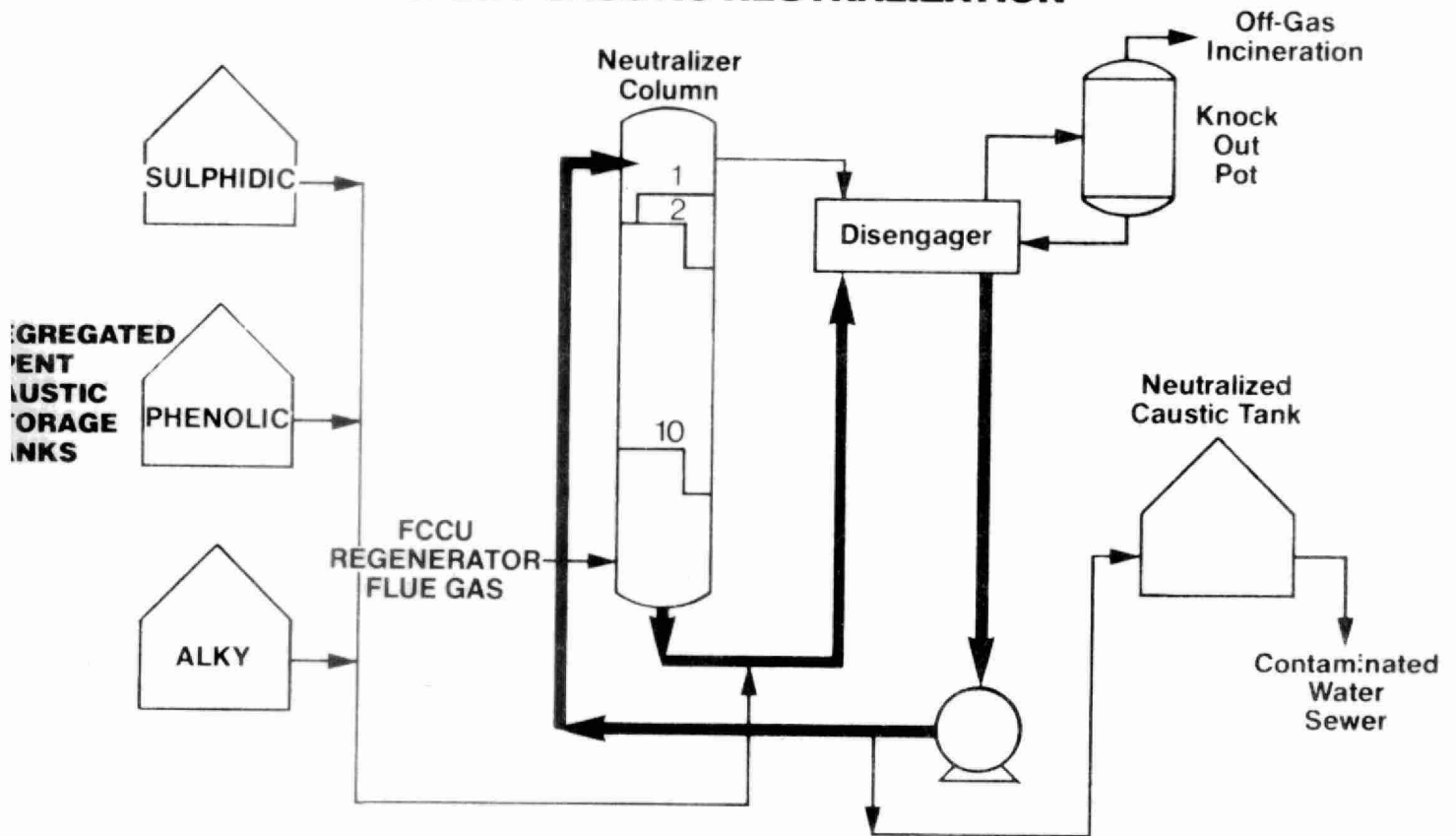
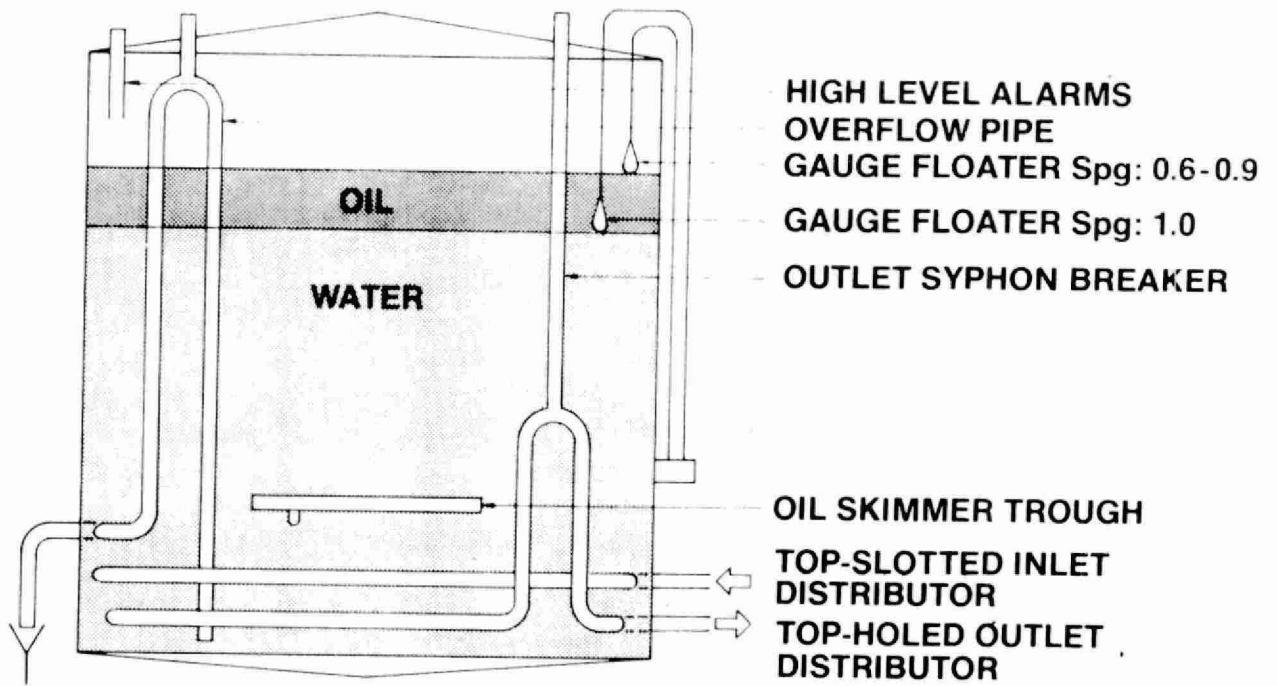


FIGURE 4

## BALLAST TANK INTERNALS



## TEXACO CANADA NANTICOKE PLANT. SIMPLIFIED FLOW DIAGRAM FOR WASTEWATER TREATMENT



FIGURE 6

## STORM WATER DIVERSION BOX

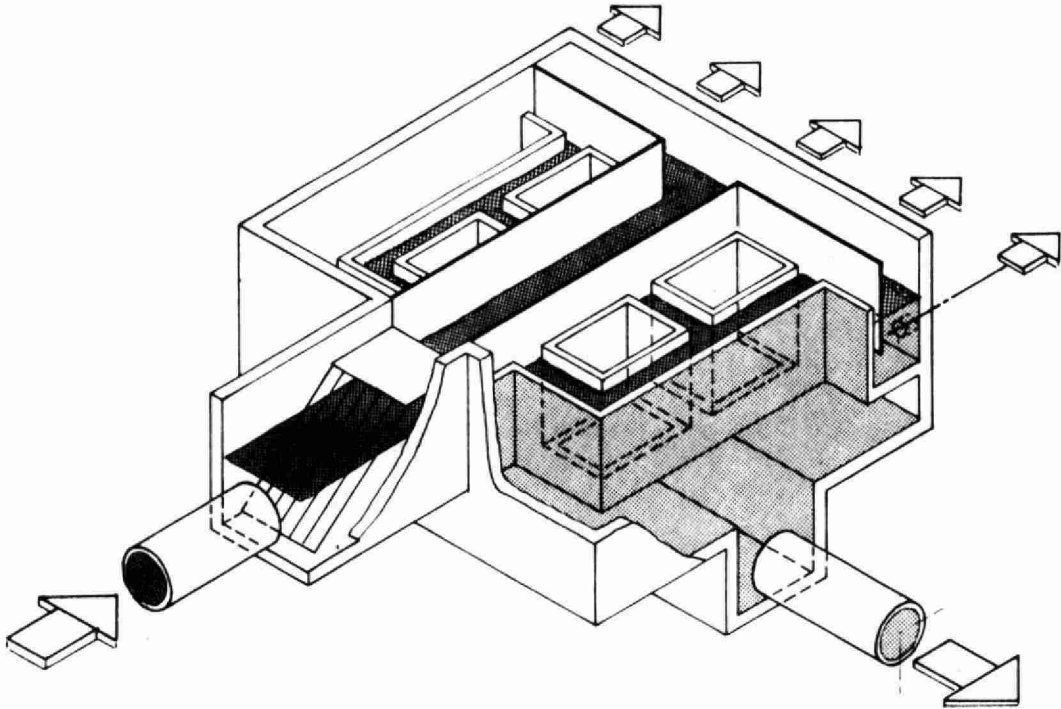


FIGURE 7

**BIOLOGICAL OXIDATION UNIT**  
Maximizing Treatment Efficiency

| CONCERN                          | CONTROLLED BY                                                                   |
|----------------------------------|---------------------------------------------------------------------------------|
| Incoming inert solids            | { Primary gravity separation<br>Intermediate dissolved air flotation separation |
| Incoming "bulking" oils & grease |                                                                                 |
| Incoming quality variation       | Mechanically mixed equalization tanks                                           |
| Non-optimal pH levels            | { Automatic acid/caustic injection                                              |
|                                  | { Mixed equalization tanks for pH buffering                                     |
| Non-optimal temperature          | Automatic waste steam injection                                                 |
| Stable biological culture growth | { Comprehensive monitoring                                                      |
|                                  | { Effective colony size control parameter                                       |
| Bio-resistant oxidizing culture  | High sludge residence times                                                     |



FIGURE 8

## **DUAL MEDIA DOWN FLOW PRESSURE EFFLUENT FILTERS**

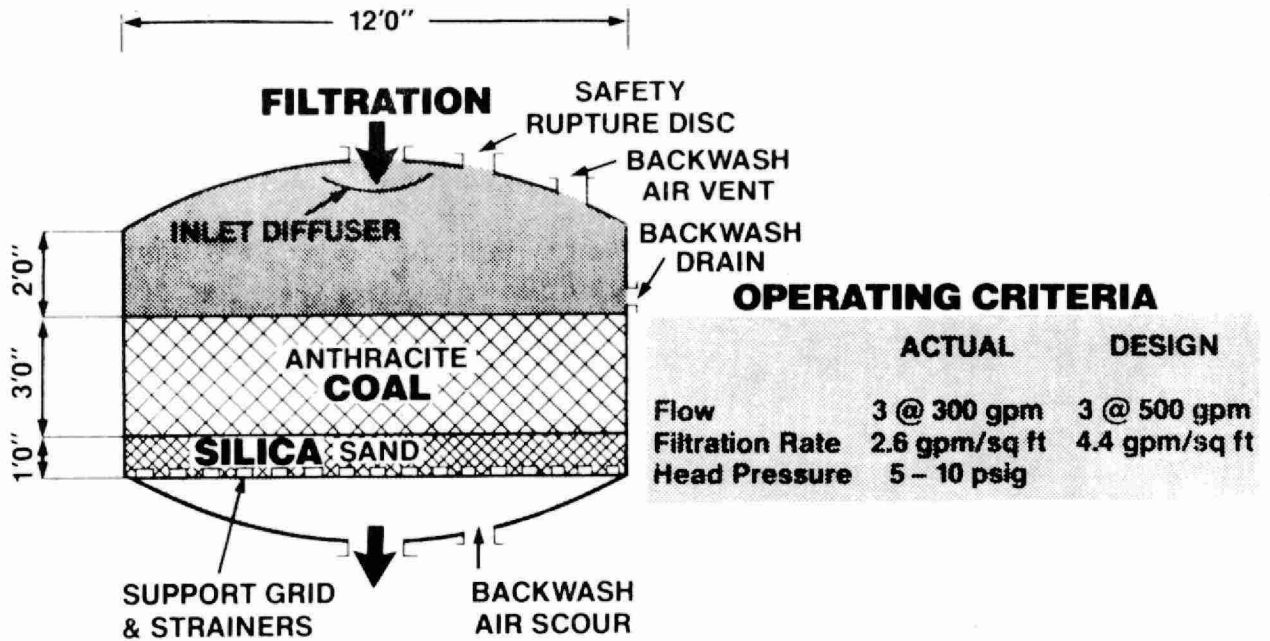


FIGURE 9

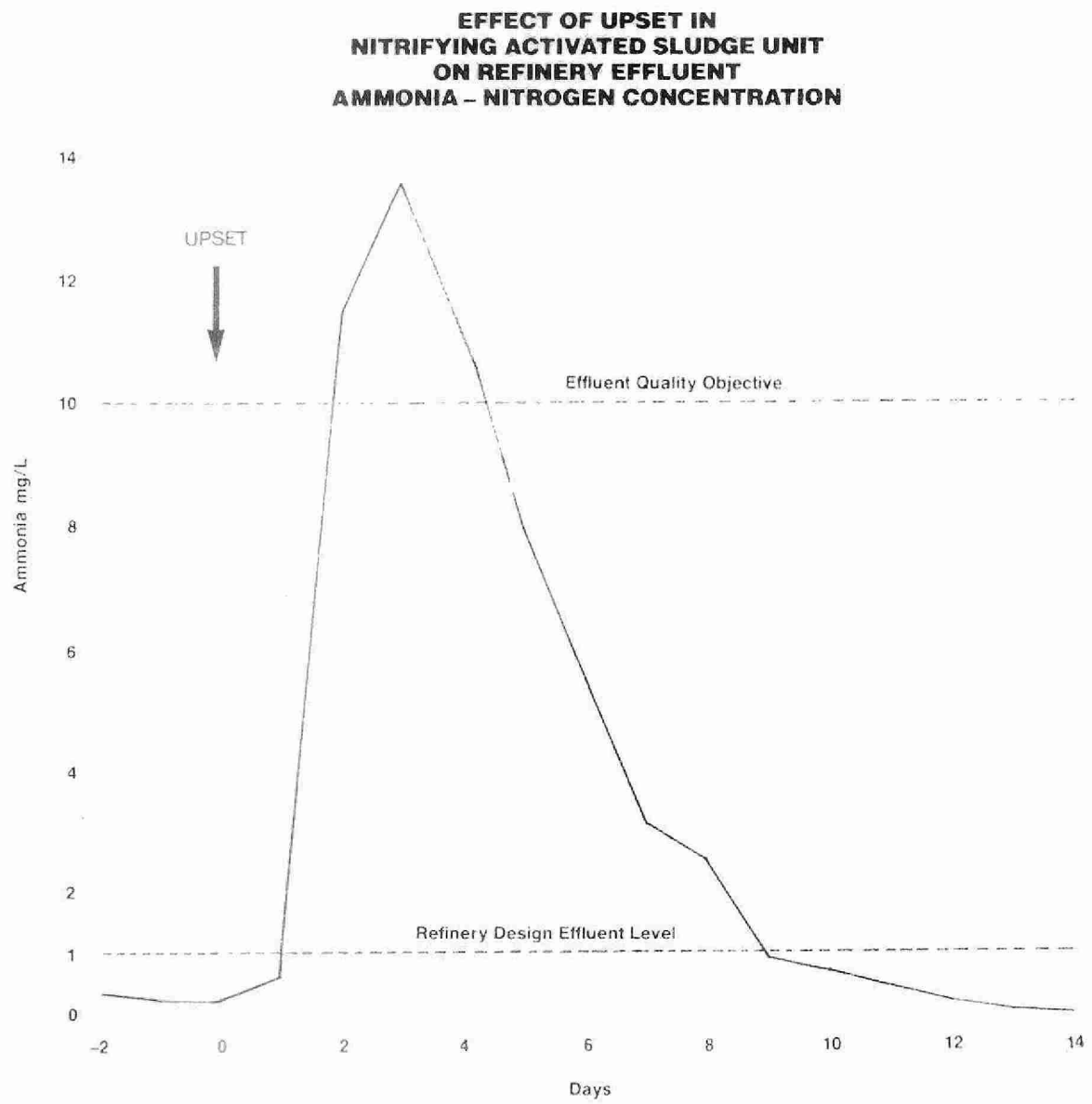
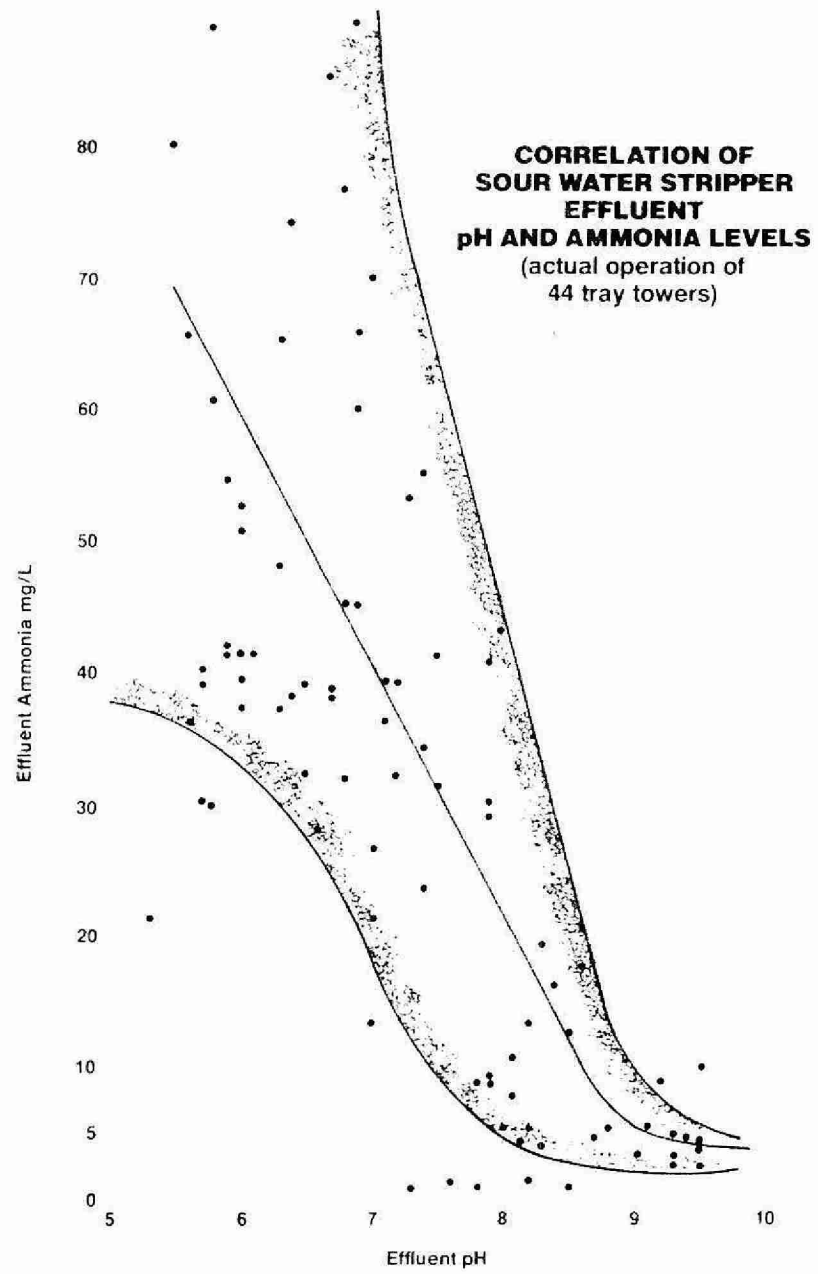


FIGURE 10



## SESSION III

### CHAIRMAN



**J. W. Giles**

Assistant Deputy Minister  
Environmental Assessment & Planning  
Ministry of the Environment, Toronto



#### **Environment Ontario's Seven-Point Program for Control of Liquid Industrial Wastes**

G. W. Scott, Deputy Minister  
Ontario Ministry of the  
Environment, Toronto, Ontario



#### **Ontario Industrial Waste Disposal—Guidelines, Regulations and Related Activities**

L. F. Pitura, Director  
Waste Management Branch  
Ontario Ministry of the Environment  
Toronto, Ontario



#### **A Journalist's View of Industrial Wastes**

Ross Howard, Reporter  
The Toronto Star, Toronto

#### **The Association's View on the Ontario Program**

A. Schultdt, Representative  
The Canadian Manufacturers Association  
Toronto, Ontario



#### **A Citizen's Concern on Industrial Waste Pollution**

W. Glenn, Pollution Probe,  
Toronto, Ontario

Liquid Industrial Wastes - Beyond the Seven-Point  
Program - The Honourable Harry C. Parrott, D.D.S.,  
Minister of the Environment, Province of Ontario

(Because of an unforeseen commitment, The Minister was unable to attend the Conference and present this paper. In his stead, Graham W. Scott, Deputy Minister of Environment Ontario attended and made the presentation).

The safe and efficient disposal of waste generated by western society's massive industrial structure is one of the major challenges in environmental protection today.

The complexity of this challenge demands the maximum in hard work and ingenuity from both government and private industry in finding long-term solutions.

I am especially pleased to be able to participate today in this 26th annual conference. You are a key group and I welcome the opportunity for constructive dialogue which this offers us.

Last October I announced a major program which is intended to resolve the outstanding problems in control treatment and disposal of liquid industrial waste in this Province.

In my remarks to the Ontario Legislature's Standing Committee on Resources Development, I expressed my conviction that the collection and disposal of liquid industrial wastes should be handled by the private sector and that there should continue to be a contractual arrangement between the generators of waste and the waste industry for effective disposal.

I see the proper role of my Ministry as acting to ensure that the methods and facilities used in the transportation, treatment and disposal of liquid industrial wastes provide no threat to health or to the environment. I believe that my Ministry has a further responsibility to provide leadership and encouragement aimed at the development of efficient waste disposal technology and safe, effective facilities.

This basic philosophy is the foundation of the Ministry's strategy for handling liquid industrial wastes.

In the seven months since our seven-point program was first announced, we are already experiencing some short-term benefits and we can see the eventual establishment of the long-term solutions which are required for the safe and efficient handling and disposal of industrial wastes.

Today I'm going to review the various elements of our program and tell you briefly where we now stand, point by point, and inform you of several new measures which we are taking.

### Way-Bill Monitoring

We want tighter controls to keep track of liquid wastes. So on January 1st, we introduced a new way-bill system, which combined with a new classification system, provides more detailed information on a specific waste load for handlers and waste treatment disposal operators.

This way-bill provides a check on any specific load of waste and gives the Ministry an overview of the total wastes produced in the Province.

It reveals the various kinds of wastes that are being produced and in what quantities. Producers of waste who do not comply with the requirements of the way-bill process are liable to heavy legal penalties.

I assure you we are not hesitant about prosecuting if wastes are not properly reported or not properly dealt with. This year to date, we have five court actions under way involving a number of companies for various violations of our industrial waste requirements.

To give you an example of the kind of information on wastes which we now gather, we know that last February, an average month, about 3.78 million gallons of liquid industrial wastes were transported for treatment or disposal. Of this, 2 million gallons were disposed in landfill, 1.4 million gallons were incinerated and 380,000 gallons were shipped to the United States for disposal.

### Classification of Wastes

We've completed a new wastes classification system which identifies various substances and which sets out requirements for their treatment and disposal. This is a definitive guide to industry. It tells generators and disposal companies which treatment and disposal methods have been approved and what is technically feasible for the handling of many types of organic and inorganic wastes spent oils, and many special wastes.

### Waste Disposal Guidelines

We have also prepared guidelines to help those who handle, store, treat and dispose of industrial wastes. These guidelines provide alternative methods for treatment and disposal to ensure protection of the environment in Ontario. And they represent the compilation of all known information and practices to date. They also reflect our intention to ban the direct landfilling of untreated industrial wastes.



Both the classifications and the disposal guidelines have been circulated to industry, to environmental groups, to waste haulers, and a variety of other interested agencies. We invited comment and suggestions for the improvement of these guidelines and subsequent regulations. While we have received much worthwhile comment from various sources, both in and outside industry, I find the overall response disappointing. In particular, I have noticed that response from industry is virtually limited to a small number of associations and organizations. We have received few comments or replies from individual companies which could be affected by any regulations.

### Regulations

There are regulations being prepared which will require registration of wastes by the generator and which will direct wastes to specific methods of treatment and disposal.

And we are proceeding with a regulation which, by December 31, 1979 or soon thereafter, will prohibit the disposal of all untreated liquid industrial waste into landfill sites. Industries which rely on this form of disposal will require an alternative method of disposal. And we are taking action to provide this.

### Perpetual Care

Finally, the establishment of a fund for perpetual care of certain wastes may be required and we are considering a regulation to provide for this.

This is a special requirement in the management of waste disposal which entails long-term surveillance of disposed wastes and, as I said, a fund to ensure cleanup of any problems in the long term.

A task force of specialists in my Ministry is working on this area and will report on some alternative approaches this summer. You will be hearing from its chairman Wes Williamson later in the program.

### Transboundary Movement of Wastes

We have been concerned in this Province for some time that the free flow of wastes for disposal across the Canada-U.S. border could be terminated, particularly for some types of wastes such as PCBs.

The U.S. government, in fact, did close the border to shipments of PCBs last January and any hauler who wished to transport these chemicals into the U.S. was required to apply for specific exemption from the U.S. Environmental Protection Agency. One Canadian firm applied and was granted an exemption to haul these wastes into the U.S. until May 1, 1980, when this will be reviewed.

We have succeeded in persuading the federal government to initiate discussion with the U.S. government and this discussion is continuing.

#### Facilities and Site Selection

As I have said, our immediate concern is the existing lack of treatment and disposal facilities in this Province and the need for interim facilities while major long-term solutions are being developed.

The consulting firm of M.M. Dillon Ltd. is working on a study of possible facilities and sites for the interim storage of PCBs until such time as permanent treatment or disposal facilities are available. The Ministry expects a final report from this group recommending site alternatives within the next month or so.

Within the next two weeks, my Ministry will request proposals from the waste management industry for the establishment of solidification facilities. These will be used for a limited term to meet the needs of those industries which will be affected by our intended ban on the disposal of untreated wastes in landfill.

I am expecting considerable interest from the waste management industry in this proposed development, and I am looking forward to reviewing their proposals.

The establishment, location and operation of these temporary storage solidification facilities will be subject to The Environmental Assessment Act.

This should not be viewed as the total long-term answer to our liquid industrial waste problem or even, necessarily, the best answer. But we are working on the long-term solutions.

A second consultant, James F. MacLaren Ltd. is conducting a study which will form a basis for Ontario's long-term plan for liquid industrial waste management and the development of required facilities. In this study, the volumes and natures of the wastes generated will be surveyed, and we expect this fall to have recommendations on the types of facilities we require and alternative locations for these facilities.

We are now planning public information and consultation programs as part of the development plan for proposed facilities recommended in both of these studies.

The type of facility and the location will be the subject of a full environmental assessment to ensure that the best available technology is employed and that facilities are located on the most environmentally suitable sites.

This entire evaluation procedure is expected to take from two to three years before actual construction of the facilities gets under way.

Once these facilities are established, Ontario will have one of the best planned and most comprehensive systems for the disposal of liquid industrial waste.

That's where we are at this point with respect to our seven-point program. We have identified other aspects of the overall challenge which we are addressing.

The technical, administrative and economic aspects of wastes disposal do not present insuperable difficulties. However, we are faced with the major problem...of public attitude.

Just about any community you can name will object vigorously to any hint of a liquid industrial waste facility in their neighborhood.

Why? Three reasons come to mind. Fear, mistrust and pure self-interest.

When I talk about fear, I'm referring mainly to fear of the unknown. Take PCBs as an example. Undoubtedly they are dangerous chemicals. They're everywhere. They've been used, stored and handled across this Province in almost every community for half a century.

I know that over the years, particularly in the early years, there has been some sloppy handling. In spite of that, there is no documentation of any serious health effects resulting from exposure to PCBs in Ontario.

We know now that the danger from PCBs results from entry into the food chain. That's why they are among the most carefully controlled and restricted chemicals in Canada. That's why we test and issue regular health advisories on the results of our fish testing program in order to ensure that people avoid a steady diet of any species of fish affected by levels of PCBs or other major contaminants.

Moreover, we have technology available to destroy PCBs in waste liquids. There are cement plants in Ontario with facilities which can be adapted to dispose of these chemicals. Currently, environmental hearings are being held to review the facility at St. Lawrence Cement in Mississauga.

When any waste disposal facility is proposed we do still get public opposition. Perhaps it's partly because of the second reason I mentioned -- mistrust.

People today don't always trust industry and government. There are acceptable reasons. Industry has not always put community interest ahead of corporate industry. And government has not always been able to perform as effectively or as quickly as the public frequently demands, especially in the area of environmental protection.

This can be in part resolved, however, by better access to environmental information; increased and wider presentation of technical facts to create an atmosphere of better understanding by the public. In other words, more and better communication so that residents are informed what government and industry are planning and have an opportunity of presenting their opinions in the conceptual stages.

We have one other public objection to contend with and that is simply, self-interest.

No one wants a liquid industrial waste facility, or for that matter any kind of landfill or disposal facility, near or in, his or her neighborhood. There comes a time, however, when all but the most biased must accept that something be done in the broader public interest and in accepting a degree of responsibility as a member of the community.

Is it asking too much for citizens to accept a facility in their community because it's the best place for it and because the facility is required to serve the public's need in general?

### The Challenge

This is the challenge we face: We're now at a stage where government and industry can work together with residents to ensure that we establish the best facilities, to run in the safest way possible.

We need to gain widespread public acceptance of the existence of disposal sites and the great need for new facilities. We ask Ontario residents to examine the technical facts and to make a judgement on the facts. We want Ontarians to know that our decisions will be based on these same technical facts.



In our society we enjoy and require the benefits of industrial and chemical technology. We simply cannot expect to reap those benefits and at the same time refuse to accept responsibility for accommodating the wastes which are by-products of that technology.

We understand the emotional reactions to the suggestion that a disposal site is to be set up in a community. But we all have to accept the fact that our communities need waste disposal sites now.

We believe that it is beneficial that the public ask questions about these sites. Will the sites be safe? Will they be clean? Is the operation going to be monitored properly.

And the public has a right to demand that waste sites and facilities be absolutely safe and that these facilities are properly monitored and inspected.

Let me assume we are successful in getting the message of responsibility across to the public, as I assure you we will be. Let's say we stimulate a more positive and constructive attitude in place of local self-interest, mistrust and fear based on ignorance.

In turn, we have a major obligation to justify the trust and confidence we are requesting and trying to instill.

How do we meet that obligation?

We will ensure the future development of effective and safe disposal facilities to meet public acceptance by applying the environmental assessment process to all major proposals.

Secondly, I have committed the Ministry to hold public information meetings concerning applications for industrial waste disposal facilities in order to give residents the opportunity to obtain full information about the proposal and to express their opinions.

We believe in this way the public will have a full understanding of what is involved and we can respond to public opinion and community desires.

At the same time, industry has a responsibility to perform effectively and in an environmentally sound manner. If we ask the public's confidence, both government and industry must earn their confidence and respect.

We are confident that, through this process, the public will accept the responsibility as well as the benefits of our industrial society.

And we believe that this understanding will provide an effective framework for the private sector to do its job -- the development and operation of the facilities and sites for waste disposal which Ontario now requires.

ONTARIO INDUSTRIAL WASTE DISPOSAL  
- GUIDELINES, REGULATIONS AND RELATED ACTIVITIES

by

LEONARD F. PITURA  
WASTE MANAGEMENT BRANCH  
MINISTRY OF THE ENVIRONMENT

Our previous speaker, Graham Scott, has referred to various aspects of my presentation. It is my intention to provide some details on the various activities of the Waste Management Branch in providing regulations and guidelines in Liquid and hazardous waste handling, processing and disposal. I will further expand on some of the interim facilities which are being considered at this time.

Way-Bill Monitoring

As previously indicated, in January of this year, a new way-bill system utilizing new forms and a classification of waste was implemented. The system as of this year consists of a semi automated computer which can provide statistical information on types of wastes, quantities, generator and disposal method. In addition, it has provided valuable information to our Regional Abatement staff in their enforcement role.

However, further improvements to the system are underway for implementation before the end of the year. The present computer system as of about November will be fully automated with unlimited stored capacities by tying into one of the main Government computers at Downsview. This will provide more definitive statistical information for the assessment of the need for new facilities as well as areas of generation. But more importantly, incomplete way-bill transactions or unimproved disposal activities will be relayed within days of the occurrence to the Regional staff for prompt follow up action. This you will appreciate will give the Ministry more credibility in respect to the private sector and public interest groups in dealing with the illicit waste handling and disposal in the Province.

#### Classification of Wastes

The present waste classification by the MOE is being updated as part of the study by James F. MacLaren Limited so that, where ever possible, the classification by the EPA, EPS, bordering states will be compatible. The way-bill form is accordingly being revised.

This revised classification will result in variations or alternatives to the disposal methods available. As well, any more definitive definition of hazardous waste as it pertains to public health and safety, handling and disposal methods, and approvals procedures will be made.

### Waste Disposal Guidelines and Regulations

As indicated by the previous speaker, a number of guidelines have been recently developed for liquid industrial waste and for PCB contaminated waste.

If I could discuss the PCB situation for a moment, a number of existing guidelines are being revised or proceeding to be proclaimed as regulations. To list a few:-

- 1) Revision of the Guideline on PCB management is scheduled to be completed this fall; this pertains primarily to the decontamination procedures;
- 2) Road oiling regulation is undergoing extensive scrutiny by an Interministerial Committee; we are currently awaiting briefs from collectors and users of waste oil;
- 3) A regulation on the movement of PCB waste equipment is to be reviewed by the registrar of regulations by August;

and

- 4) A guideline on PCB's in synthetic fuel is being finalized for issuance in the near future.

Concerning liquid industrial wastes in general, a number of regulations are being prepared for proclamation by this year's end. These include:-

1. The classification of waste to become a regulation including descriptions of hazardous materials;
2. The method and possibly the actual disposal facility become regulated;

and

3. Prohibiting untreated liquid industrial waste being disposed of in sanitary landfill sites effective January 1, 1980.

### Site Identification Program

The Ministry is often faced with the problem of providing information relating to development on lands where, at some time in the past, there may have existed some waste disposal facility or activity. (Section 46, Part V, EPA). If the Ministry is to provide meaningful information, and identify potentially hazardous situations, it is essential that we undertake a comprehensive survey of the Province to identify these areas.

The objectives of this particular study are as follows:-

- 1) To identify and record the location, size, volume, dates of use, types of waste, etc., available on waste disposal sites, domestic and commercial, industrial, solid and liquid, public and private, prior to 1971 when present certification system and records were established and any additional sites where wastes may have been disposed of without the knowledge of this Ministry.
- 2) To ascertain the existence of "Rumoured" waste disposal sites, where no municipal or private records exist. This information will enable the Ministry to control development or activity on sites not previously documented.

A contract has been awarded to York University to survey Southern Ontario. York will be using approximately ten students starting on June 5 and continuing until early September. We are currently negotiating with the Northern institutions to carry out the same work in Northern Ontario. In particular the students (mostly graduate researchers) will look into all archives, public health unit and municipal records and contact the town people etc., to find what information is available to the Ministry on these sites.

In conjunction with this program there is a study presently underway to ascertain the possibility of developing remote sensing techniques for establishing further information with respect to the sites found on this study.

This survey is just one aspect; we can anticipate that additional field work will be reviewed in the next year or two to confirm whether there are problems or potential problems. This would then be followed by corrective work to be carried out by the owner.



Another exercise in conjunction with this study is the initiation of a review of the inventory of all active and inactive sites certified since 1971. It is planned to reissue new certificates which will identify the types and volumes of wastes that they are approved to handle. As an added precaution it is planned to have all of the certificates registered against title to be certain that owners of the lands are aware of the provision of Section 46 of the Environmental Protection Act.

### Interim Facilities

We have discussed this morning a number of activities of this Ministry in regulating or providing guidelines for the disposal and handling of liquid industrial waste and to some degree hazardous waste. However, we are all aware by this year's end there will likely be a continuing lack of adequate facilities for the handling of these materials. To this end, a number of alternatives are being seriously considered to provide long-term or interim facilities by January 1, 1980 when untreated liquid industrial wastes will no longer be acceptable at sanitary landfill sites.

One of the more promising proposals is by the Regional Municipality of Durham, which is presently preparing an application for the conversion of the Ajax water pollution control plant to a liquid industry waste treatment facility. This would make use of a pollution control plant which is scheduled to go off-line as a result of the start-up of the York/Durham scheme. The present schedule calls for a public hearing to commence in October of this year.

Based upon the studies to-date, the Ministry is presently negotiating an agreement with the re-

gion to fund up to 80 per cent of the engineering and approvals procedure cost. If successful, the Ministry is considering providing the capital cost for the conversion of the plant which would be refunded from revenues gained from the operation itself.

Secondly, the Ministry, as has already been mentioned by Mr. Scott, has requests for proposals prepared and will be submitting them to the private sector shortly for the establishment of one or two limited term solidification plants whereby the final material is stored on site. The Ministry will be prepared to assist in the sharing of costs for the hearing process. This is an example of our seriousness in ensuring that appropriate facilities are provided for Ontario needs.

A number of demonstration projects are being funded or being considered for funding by the Ministry to evaluate technical viability of certain processes. These demonstrations may provide a number of facilities available on the market for full-scale development into

operating plants for solving some of the liquid waste disposal problems we now encounter.

A number of private firms have made submissions to my Branch with regard to their particular proposals and to some degree site specific applications. In keeping with our policy, the Ministry is co-operating with these private firms in an attempt to establish facilities.

#### CONCLUSION:

Although we are embarking on an extensive program for the control of liquid industrial wastes, the Ministry cannot solve the problems without the co-operation of industry, municipalities and the citizens.

I can only repeat in part what Mr. Scott has said earlier. There has to be increased public trust of government and industry; in turn government and industry has to perform in a responsible manner.

We believe we are moving in this direction; I am sure you in the audience representing industry want to be, and will be, part of this movement.

A Journalist's View of Industrial Wastes  
by  
Ronn Howard, Toronto Star

Good morning. I'm not sure why I'm up here. My better judgement tells me this is the last place an environment reporter should be. Environment is considered a "bad news" assignment these days, and there's a nasty trend towards attacking the bearers of bad news. I know. I just went through three days with the nuclear industry.

Further, why have you got a journalist up here anyway? As reporters are regularly told, "We've got the facts wrong".

Nonetheless, and at the risk of being quoted, let me say thank you for the invitation to speak. I just wonder why I accepted it.

You've asked for a journalist's view of industrial wastes. Unless you are elevating the media to a previously unrecognized position of wisdom and vision, I think what you are really after is an allegedly unbiased version of the public view of -- and here I shift to the public's terminology -- political and industrial garbage. If so, then perhaps I can help.

I say this because what the public knows, and fears, about industrial, particularly toxic, wastes, may not be the whole truth. But as events in Ontario as well as elsewhere have proven, the public perception often becomes the reality. There certainly is a toxic wastes crisis in Ontario because the public believes there is one. And neither the government nor industry is to be believed when claiming this fear to be groundless. Personally, I think the public is right. To use your industry's worst affliction as an example, who in their right mind would believe Hooker Chemical anymore?

It's true that much of the media's intensive reporting now of toxic waste issues is partly in response to, and a reinforcement of, that public impression. But I remind you that we in the media didn't dream up the subject because ad revenue and circulation was low. Long before Love Canal we had indications that something dirty was under foot.

It can, and has been argued, that the media has sensationalized the issue. Perhaps, but sensational news stands on its own, and Love Canal, for example, is a sensational fact. It needs no embellishment by the media.

What's with this fascination with Love Canal? Simple. We all live across the lake from Love Canal. We all live in and emulate the image of America. We generally behave like Americans. It is natural and prudent to look and fear for the consequences of shoddy toxic disposal tricks here, across the lake.

The Minister says there is -- and I quote -- absolutely no fear of a Love Canal in Ontario. He may have no fear, and I admit he's been braver than the last couple of Environment Minister's we've gone through, but the public certainly fears. And perceives. And with good reason.

Let me outline some of those reasons, admittedly in no particular order but simply culled from recent clippings, reports and comments; and my own assessment:

Again, these are in no particular order. But consider:

- \* There are at least 2,000 landfill sites in Ontario.

\* Pre-dating 1971 there is no systematic information on those sites contents, let alone location. Ministry of Environment officials openly admit they don't know where to look. The government has set \$59,000 to send students out looking, this summer.

\* In the U.S., a superfund taxed upon producers and haulers of toxics to cover costs of emergency clean-up of future abandoned toxic dumps, is about to be imposed. Ontario talks of a perpetual care fund. But how. And when?

\* At Maple, appeal hearings on the giant dump scheme are tangled, during very sporadic sessions, in questions about the Appeal Board's right to hear a new application. The rules seem terribly unclear in Ontario.

\* In Toronto, the Federation of Agriculture attacks the government for "failing to steer wastes away from good farm land".

\* The International Joint Commission, in 1977, lists 12 licensed Ontario hazardous waste dumps, 75 liquid, 8 deep well, 1,108 solid waste, and 106 closed or abandoned. This last figure is impossibly low.

\* Etobicoke and Mississauga -- the municipalities want power to start crisis clean-ups and bill the offenders, without waiting for the Environment Ministry to act.

\* York Region -- the council wants to take direct ownership of the proposed Maple dumps to ensure "better control".

\* Hamilton -- the Upper Ottawa Street Dump -- 100-plus charges laid.

\* Durham Region -- small industrial operations are dumping directly into municipal sewers undetected. September 1978, the municipality is forced to flush 300,000 gallons of raw sewage into Pringle Creek because of a system overload.

\* Queen's Park -- the Ministry says it has 14 potential sites for PCB disposal and storage, but can't reveal them for fear of public protest. The sites were selected with \$60,000 in public funds.

\* Queen's Park -- all waste sites of the past 20 years should be catalogued and monitored, landfill should not be used for toxics, industry should pay the disposal costs, not citizens -- report of the Resources Development Committee December 1978. What action? None.

\* Ontario -- more than 50 million gallons of industrial wastes produced per year. Last year the Ministry couldn't find 20 per cent.

\* Halton, Milton, Caledon, Peel Region, Maple, Wentworth and more -- the municipalities are saying no more dumps here. Where is the stuff to go?

\* Queen's Park, early 1979 -- the Minister says every landfill site, active or closed, is being examined. His staff say this is impossible. They don't know where to look. The summer students won't find very many.

\* Love Canal -- the U.S. EPA estimates the minimum direct remedial cost to be \$40 million. Lawsuits already exceed \$2 billion.



\* Washington -- and this one particularly galls me -- the Manufacturing Chemists Association -- a big lobby group -- claims new toxic dumping laws will skyrocket the costs of production. The EPA does some real number crunching, and finds the laws will cost only one-third of one per cent of actual gross sales. This game is known as environmental blackmail.

\* Queen's Park --the opposition parties present various lists of potentially unsafe dumps. The Ministry errs in reply, then slowly corrects itself, but fails to issue a definitive list.

\* The Canadian Environmental Law Association presents a major review of inconsistencies in Environmental Assessment Board procedures re: Dump Hearings 1978. Many of the items actually support Rusty Drew's long plaint on behalf of industry as presented at this conference last year. Any action to fix the warped board yet?

\* California -- fines for first offense illegal dumping are \$25,000, highway patrol officers police haulers, and inspectors use unmarked cars. In Ontario the fines are \$5,000. There are no Ministry staff available to drive unmarked cars.

\* And finally: The Minister's seven-point plan of action.

\* The waybills have been introduced and upgraded but now they need revision again. More importantly, charges laid June 9, re: certain wastes activities in Maple leave an impression that a way to easily subvert the waybills has been devised. So far, Ministry staff have refused me, and other reporters, any details to clarify this.

\* The Ministry guidelines for PCB storage and disposal -- if they are guidelines, they have no force in law.

\* The January 1980 deadline ban on dumping in landfill -- there's nothing to suggest the industry is ready for this with engineered-safe sites. Where are these approved safe sites?

\* Interim storage sites are to be established. Where? When? Owned and operated by whom?

\* The perpetual care fund. Where is it?

So far, I've largely been referring to liquid wastes. One more for solids: Metro Toronto threatens to ban commercial-industrial garbage from its few remaining dumps as first step when the crunch comes. Industry claims this would have immense cost impacts on them. The costs aren't proven, but even so, if true, what has industry done to reduce the packaging and find alternative disposals? And government initiatives; the Downsview garbage gobbler and sorter is small scale, Watts From Waste is on the back burner again in year 8, and Dorton Steam Heat is hardly a hot item with governments.

And finally, can somebody name me a community which wants another garbage dump? They don't know or fail to believe that such dumps are really engineered sanitary landfill sites.

I could go on, but I hope you see my point. What am I supposed to do with all this information? Don't tell me what you're thinking! If you were a journalist, what would you do?

Based on this kind of information, it is not sufficient to say there is no danger of a Love Canal here. And saying so won't avert it.

I must add that the industry -- producers and haulers -- is saying far too little, which makes me suspicious instead of just cynical.

There is a gross lack of definitive information. There are monstrous gaps in our toxic legislation compared to the U.S. There are conflicting jurisdictions. There is public fear, distrust and not necessarily irrational opposition. There is lamentably slow progress. There is doubt.

Let me take this a little further:

In Ontario, we are far from clear on who is responsible for toxic waste disposal. I suggest the provincial government -- the feds really have extremely limited relevance here -- has been caught in a squeeze play of its own making: unable or unwilling to apply sufficient pressure on the toxic-producing and hauling industry to bring that industry to serious self-regulation and good conduct. Unable due to seriously inadequate staff and resources, and a historic role in this Province as negotiator rather than knuckle-rapper, and unable because of the Cabinet's own philosophical hang-ups about public service versus private industry. On the other side of the squeeze, the government is now pressed by a disbelieving and frightened public, a moderately aggressive media on this issue, and a recognition the issue could prove politically fatal, should a Love Canal be found. Some action, any action, must be taken.

And yet, we also have the industry, both the producers and haulers, alternately demanding freedom from regulatory interference and bureaucratic costs, yet claiming that the government just step in and solve the crisis of sites and approvals.

The red tape the industry complains about -- Rusty Drew can repeat his Nanticoke story -- is, I suggest, the least the government can do to ease the squeeze it faces. I suggest it is better for industry to unravel red tape than to become part of it -- an entire waste haulage and disposal industry owned and operated by the government. And a toxics producing industry with no choice of disposal sites, systems and rates.

I personally think the producing and hauling industry should be responsible, from cradle to grave, and the government should ensure this responsibility is met, rather than meet it for a negligent or disinterested industry. I can't seriously believe that the toxics industry can't find a solution, including a solution to dealing with red tape and public distrust. The solution will admittedly involve some additional cost to industry. But it can and will be passed on to the consumer. It always has been. And in so-called healthy industries, those who manage most wisely and pass on as little as possible are considered most competitive and healthy, as the argument goes.

A few more comments in what is probably becoming my self-immolation as a social critic. Now you know why journalists prefer to write about politicians than be politicians. We don't have to stand for election. We criticize things, rather than rationalize them.

So far, I think the industry has let the government take the flack, and squeezed into jelly as it is, the government has lacked a clear and aggressive position to counter that flack. Fair enough, but a Love Canal in Ontario would -- will? -- change all that. In response to public outrage, the government will respond with a sensational barrage of industry regulation and interference. Look at the U.S. situation. Look at the Occupational Health Bill 70 in Ontario. Look at the battering Ontario Hydro is taking now.

I'd truly like to hear much more from industry on what it can do to solve the crisis, and what strides it has already made, and how it is going to beat the government to the punch. What will be the costs? The real ones, in hard dollars and cents. How do these compare to direct and indirect public and private costs of toxic poisoning? Give me some good old risk-benefit analysis.

I suggest both government and industry are in a race now to be best prepared for a Love Canal, and avert future ones. It appears to be a race between a streamlined turtle and a paraplegic rabbit. The loser will pay - we all will pay.

And finally, let me outline the questions I need answered if I'm to stress the Minister's claim of no Love Canals here. I'll even give the answers.

\* How soon will Ontario have a fully effective toxic wastes control program in effect? Including no dumping in unprepared specific sites? January 1981. That date gives the Ministry one year to delay after the Minister's earlier deadline. That's enough time, for both the industry to accomplish what it has been facing for several years, and for the government to have built strong mechanisms to enforce compliance.

\* What will be the financial implications of tough regulation? With some exception for small industries, which could be aided by loans -- not grants -- the industrial cost will amount to something as low as one-third of one per cent of gross annual sales in toxic producing industries. Prove me wrong if you can.

\* Are there any Love Canals in Ontario? None that we know of, but on evidence and hindsight there are probably dozens of sites where wastes have been improperly disposed of. We need to find these quickly and tackle them with a prearranged fund.

\* What is industry doing about abandoned sites? Creating an industry-funded team to work with government inspectors, using wide-open industry records, to confirm the status of every detectable site.

\* What is the government doing about abandoned sites? Expanding its summer student search with more Ministry staff. Let the question of funding be resolved directly in the Legislature. Let the opposition parties determine if the issue isn't worth funding.

\* What can the public do about toxic wastes? I'd love to hear the Minister echo his U.S. counterparts and say this: Become involved. Read the joint Industry-Ministry handbook on toxic waste disposal -- no such handbook exists -- then join an environmental group or other concerned organization. And press Legislators hard for faster action.

\* When a proposal is made for a toxic dump site, what can the public do? Insist on and participate in a public hearing. If Ontario is to have safe storage and disposal of toxics, then it must have the confidence of the public. Gained through public hearings. Industry must accept the public's right to learn, however slowly.

Is all this extra staff, money and paperwork really necessary? Yes. The problem is extremely complicated and it is sadly neglected. But like cancer, it cannot be neglected for very long without irreparable or fatal harm.

I've spoken about public and media perception of our toxic wastes crisis. Perception can be created by action or inaction. But I suggest this perception can only be changed by action. And we need more action from both the industry and the government. I look forward to reporting the outcome. Either way, it's news. I hope it's reality too.

**VIEWS ON ONTARIO'S WASTE DISPOSAL PROGRAMME**

**Some Remaining Issues**

**by**

**A. A. Schuldt**

**Assistant Environmental Control Manager**

**The Steel Company of Canada, Limited**

**on behalf of**

**The Canadian Manufacturers' Association**



Some people worry about the potential long-term effects when waste is disposed. Others cite instances of poor disposal practices. Another group believes that recycle and reuse is a panacea for handling all types of waste which society generates. Some champion the idea that industry must solve the problem. Clearly, many views exist and one can identify valid concerns and genuine interest to solve the problem. The fact that the matter is being studied and discussed is important by itself. Perhaps we are getting somewhere. Unfortunately, the necessity for more treatment, the risks involved, the methods to be used and the magnitude of the problem remains unclear. The time has come to be more specific about what is to be done, by whom and how. This requires careful consideration and an assignment of tasks. The Government certainly has a major role to play in this.

The goal should be to do it properly and basically this means finding ways that will satisfy the concerns of the public and industry alike. But before progress can be made, a plan is needed. More importantly, those who are directly affected must be informed about the plans. Indeed, waste disposal touches society in all areas, namely:

- Government, as they plan and regulate
- Public Sector, as they seek protection against perceived environmental disasters.
- Industrial Sector, as they attempt to control waste volume and provide more treatment and/or proper disposal facilities.

In each instance the concerns are different and eventually a compromise will have to be worked out. Without minimizing the

problem, it is apparent that we are not faced with a lack of technical solutions. Instead, we are saddled with a number of frustrations.

There are perhaps three important points to consider. In the first place there is reasonable doubt about priorities and the willingness to collectively change our current practices and attitudes to lessen overall environmental risks. This is supported by the fact that new sophisticated treatment facilities and disposal sites for liquid industrial waste are not being approved.

Secondly, the goals which are to be achieved are not clearly defined. How much treatment is required? Are present methods actually sufficient? These are some important questions which must be addressed in detail.

Finally, a difficult situation was created by the Ministry's pronouncement that liquid industrial waste cannot be disposed of in sanitary landfill sites after January 1980, even though it was apparent that alternative disposal methods could not possibly be ready in time. It is unlikely that any hearing process could be completed that quickly even if there are sites or facilities to be approved. It is difficult to see how this timetable can be met.

While January 1980 is the target date, municipalities have already moved to restrict or limit liquid waste that they are willing to accept. Consequently, waste haulers are finding it increasingly difficult to find locations to dispose of material.

In summary, the situation continues to be in a state of flux and is becoming more pressing without a real indication of when or how the frustrations might be eliminated.

Today I would like to elaborate on these problems and suggest some areas which ought to be explored further and comment on programmes which are underway.

#### Treatment Facilities

The problem is due to the absence of comprehensive treatment facilities and disposal sites close to the major industrial sectors. Getting disposal sites approved is the missing link. In order to overcome the problem, it appears to be necessary for the Ontario Government to take positive action. It seems that a spark was struck months ago when consultants were retained to study, in detail, problems associated with site selection, treatment design and operating criteria, to name a few. But, equally important, the study is expected to address social concerns as well. That is certainly good news.

Obviously, recent events have demonstrated that solving social needs is as important as solving the technical problems. The surprising fact is, though, that we are still inept when it comes to dealing with non-economic issues. The most frustrating stumbling block is to convince people that a proposed disposal facility in this or that location is necessary and environmentally safe. There is an important need to develop convincing arguments and, therefore, it is encouraging to see that a greater emphasis is now placed on these concerns.

By articulating and solving some of the social problems it seems more likely that appropriate criteria will evolve for siting, designing and operating disposal facilities. While the basic process technology is known, guidelines are lacking pertaining to the environmental requirements for siting and operating a disposal facility. This seems to indicate that perhaps earlier attempts to get facilities approved were premature since important facts were missing. There is a need for Government to give direction in these matters and, for instance, define what amount of site protection would be required to control leachate migration and what indeed would be deemed acceptable leachate. It is clear that without such guidelines it would be difficult for the public to judge if a proposed disposal facility is environmentally safe.

Basically, the points mentioned deal with the foundation which should be in place before new initiatives can be expected from interested parties to develop comprehensive treatment and disposal facilities in the Province.

### Needs

Although industry has reduced its liquid waste volume by using a variety of methods, about 45 million gallons remain and must be disposed. The quantity is divided about equally between organic and inorganic waste. Unfortunately, this waste covers a wide spectrum and this adds to the problem.

This is not to imply that there is a 45 million gallon problem; on the contrary, a substantial amount is disposed of in an environmentally acceptable manner by incineration or solidification and, in some cases, by landfill. Unfortunately, existing facilities are not capable of handling all the material which is generated and, instead, some waste has to be transported to disposal sites outside the Province.

From an industrial point of view, the situation is not entirely satisfactory and more permanent local sites are needed. In summary, the reasons are:

1. Some waste cannot be disposed of within the Province because suitable treatment methods are not available. More sophisticated technology is required locally.

2. Relying on sites which are located outside the Province is risky because borders might be closed. Parochial attitudes are growing and there is a definite need to be self-sufficient.
3. Transportation distances are long. This adds unnecessary cost penalties and these problems will be aggravated by fuel cost increases and/or fuel shortages.
4. Providing more treatment at each plant is not generally the answer. It is usually more cost-effective and environmentally beneficial to treat liquid industrial waste at centrally located facilities which are operated by specialists.

There is ample evidence which would support a policy of developing new disposal facilities but some further work is required before such facilities could be sized and designed. More specific information is needed regarding type and volume of waste. For instance, it would be inappropriate to insist that waste be treated at these new facilities for the sole purpose of keeping the volume factor high when present disposal methods are environmentally adequate. This should even mean that unless there is something definitely wrong with disposing liquids in sanitary landfill sites, landfilling ought to be allowed as another option. Obviously a careful distinction between what is acceptable in landfill and what is not must be made. It is not apparent that we have all the facts at this time or even that there is an effort being made to determine when landfill is acceptable.

## The Cost Issue

It can be stated in different ways, but what is needed is to dispose of waste liquids at the lowest cost without impairing the environment. Alternatives to disposal have already been suggested for implementation, namely to reuse and recycle material. Certainly examples already exist where material which was formerly considered a waste is now a secondary raw material for another operation. Pickle liquor from steel plants is a typical example. Spent acid which is rich in iron is an effective chemical for removing phosphate from sewage. No doubt there are other potential cases which would become economically attractive should waste disposal costs climb, but economic forces tend to distort and continually change the picture. The amount of waste that would be available at any particular time to an independent waste disposal operator would not remain fixed as costs change. Consequently, planning is difficult. However, there is a generally believed fact that, provided treatment costs are reasonable, generators would use the new disposal facilities since alternative schemes usually require additional capital expenditures and maintenance at the plant site as well.

Therefore, it is logical to suggest that ways should be found to assure that waste treatment will not become an excessive cost burden. This might be accomplished through long-term, low cost government-sponsored loans. As well, other forms of assistance would be helpful in solving the existing waste disposal dilemma and the more important one is to secure site approval.

### Regulations and Guidelines

Since the Ontario waste disposal programme also involves regulations and guidelines, it would be appropriate to consider the implications of two important documents, namely:

1. Bill 24 - An Act to Amend the Environmental Protection Act,  
and
2. Guidelines for the Treatment and Disposal of Hauled Liquid  
Industrial Waste.

First, the fundamental thrust of Bill 24 is to broaden the authority of the Minister in order that he can act more expeditiously to control spills. As well, new absolute liability responsibilities will be placed on waste generators. Ownership and liability are intertwined and this raises some concerns. As the draft stands, it could mean that if environmental problems are encountered in later years (for instance after waste has been landfilled) the generator could be held responsible for damages unless specific contractual arrangements were made to transfer ownership to the disposer. The implications are worrisome since, in most instances, other parties may be involved in treating and disposing the final residue. To place potential liability on the generator, even if waste has been disposed in a proper disposal facility, seems to be an unrealistic approach. It is more realistic to involve the parties who are directly in control and that is the disposer of the material.

The scenario, then, introduces the next subject of liability protection.



For instance, can adequate protection be obtained via traditional third party insurance schemes and could smaller companies afford the added premiums? More importantly, what would be adequate coverage? Obviously, considerable work is required before the impact of this added responsibility can be fully assessed.

There are other areas which create difficulties and The Canadian Manufacturers' Association has submitted more detailed recommendations to the Minister. However, the Association is in general agreement with and supports most of the basic objectives of the Bill.

Secondly, guidelines which were issued for the treatment of industrial waste are useful in ensuring proper disposal. Some basic guidance is now available regarding appropriate treatment. There is one essential comment which should be made, namely, the guidelines should not be changed to regulations. It would be extremely difficult to define precisely all the waste categories which might be encountered and to assign treatment methods. But by retaining the compendium as guidelines, flexibility is maintained and this is an important point as options and strategies evolve. Furthermore, experience must be gained with new approaches.

Perhaps, as a final comment, it seems that the guidelines could stress more strongly the importance of applying reuse and recycle principles as an alternative for waste disposal.

Indeed, sometimes practice changes result in more profitable operations as well.

### Summary

The following points should be emphasized:

1. It is necessary for the Ontario Government to continue taking action by obtaining necessary approvals for at least two environmentally acceptable sites.
2. The Ministry of the Environment should establish appropriate criteria for disposal site selection, plant design and operation. The recently initiated study report should be completed quickly and industry's views should be sought.
3. Efforts should continue to identify social concerns and develop convincing arguments pertaining to the need for centrally-located disposal sites and that these facilities are environmentally safe.
4. An extended timetable is required for building new alternative treatment and disposal facilities before prohibiting the use of disposal methods which might not be entirely satisfactory. Interim storage is an inappropriate solution.

5. Inadequate disposal facilities should be upgraded rather than being closed.
6. An improved awareness programme is required to inform those who are directly affected. It is important to establish lines of communication for an ongoing information exchange programme in order to identify priorities and obtain agreement on moving ahead. Hopefully, through such action, unnecessary confrontations can be avoided.

## A CITIZEN'S CONCERN ON INDUSTRIAL WASTE DISPOSAL

WILLIAM GLENN

POLLUTION PROBE

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Effective waste treatment and disposal requires the co-operation and involvement of an informed public. Access to information and environmental assessment hearings are vital for gaining public support for a new control program. William Glenn, who deals with toxic waste issues in Canada, will offer his perspectives on the government, industry and public initiatives needed to find a solution to the liquid waste disposal problem in Ontario.

NOTE: Mr. Glenn spoke from notes and personal observation and did not provide a full written text of his address at the Conference.

## SESSION IV

### CHAIRMAN



**Ian McKerracher**

Director, Refuse Disposal Division,  
Metropolitan Toronto Works Department



**The Federal Approach  
to Hazardous Waste Management**  
T. E. Rattray, Director, Waste Management  
Branch  
Environment Canada, Ottawa, Ontario



**Siting of Hazardous  
Waste Management Facilities**  
C. A. Johnson, Technical Director  
National Solid Waste Management  
Association, Washington, D.C.



**Transportation of Hazardous Materials**  
J. M. Gaudreau, Chief of Operations  
Division for Transportation of Dangerous  
Goods  
Transport Canada  
Ottawa, Ontario



**Perpetual Care  
for Waste Management Facilities**  
W. Williamson, Manager  
Waste Utilization Section, Waste Management  
Branch  
Ontario Ministry of the Environment  
Toronto, Ontario

The Federal Approach to Hazardous Waste Management  
by  
T.E. Rattray, Director, Waste Management Branch,  
Environment Canada, Ottawa, Ontario

Managing toxic and other hazardous wastes now ranks as one of the highest priority environmental concerns in all regions of Canada. This paper examines the problem in Ontario and other provinces from a national perspective. Although centres of industrial concentration, such as Southern Ontario, exist across the country, a great deal of Canada suffers the economic hardship of long distances between points of manufacture and ultimate markets. While this phenomenon is not new to business in Canada, it has not traditionally been a problem for the waste management industry. The hazardous waste problem is unlike the municipal refuse problem in many ways including the involvement of senior government. The activities of the Federal Government in the managing of hazardous wastes from the early 1970's until present are described.

Major developments in the past year that could have a significant impact on the future of hazardous waste management in Canada are presented. Factors such as the regulatory process in the U.S.A., transportation and transboundary controls, technology developments, incidents like the "Love Canal" unearthing, and the enlightenment of environmental interest groups and the general public have combined to create a new framework within which solutions to the hazardous waste problem must be developed. The responsibilities of all levels of government and the private sector in a cooperative effort to bring the current problem under control are discussed.

NOTE: Mr. Rattray did not provide a full text of his paper for incorporation in the printing of the Proceedings of the Conference.

Siting of Hazardous Waste Management Facilities  
by  
C.A. Johnson, Technical Director, National  
Solid Waste Management Association, Washington

It is a great pleasure to be with you today here in Toronto, a city that by any measure must be among the most dynamic and exciting of the metropolitan areas of North America. As a youth, I lived just across the border in Buffalo. I recall then that the two cities were quite similar in appearance - neither conveyed the impression that it enjoyed great prosperity. I spent last evening in Buffalo and it appears to me that the past 30 years have done little for my home town - but Toronto - What a different story.

Prosperity brings with it certain problems along with its obvious benefits - not the least of which is the problem that societies - primitive and modern, simple and complex - generate waste materials as a result of their prosperity and affluent. Solutions of the past have been largely on the old fallacy - out of sight, out of mind. Now we find that some of our simple solutions to complex problems of waste disposal were not solutions at all. Our society has reached the point where it cannot afford the simple, non-solution, no matter how economical they may appear at the time.

When I first joined the National Solid Wastes Management Association as Technical Director nearly two years ago, one of the first trips I took was to right here to Ontario. I was particularly anxious to inspect the chemical wastes management facilities in operation here and what I saw impressed me considerably. My trip took me to the Tricil Chemical incinerator in Mississauga, then past the St. Lawrence Cement Co., where liquid PCB's had been successfully destroyed in a test burn, and finally to a place in Hamilton where a new chemical fixation process for heavy metal wastes was being tested on a large scale.

Surely, I thought in reaction to these visits, Ontario has its act together in the management of its chemical wastes.

But now less than two years later, the story is much different, the chemical incinerator has been shut down, reportedly from lack of business, the cement plant still does not have a permit to burn PCB's and the chemical fixation process is still a very restricted operation.

What a dilemma we face! We know the problem, we have the solutions and yet the private firms that comprise the hazardous wastes management industry are being frustrated in many ways as they attempt to perform their function.

The National Solid Wastes Management Association has devoted a substantial effort to investigate the siting problem and come up with a solution to recommend to local, state and provincial governments across the United States and Canada. This afternoon, I want to share with you some of our thinking on this matter.

Before I do so, however, let me digress a bit. Some time after we had spent many hours in committee meetings sharing experiences and ideas, on past siting efforts, I happened to pick up a copy of Civic Public Works magazine and found several articles on hazardous wastes management in some of the Canadian provinces. One article reported on a speech by Ted Rattray and it contains a paragraph that is so pertinent that I want to read its verbatim with due credit to Ted,

"In recent times in Canada the problems of waste disposal have been approached on a site-by-site basis. The lack of



any master plan has resulted in the focus of attention at environmental hearings being on individual sites as opposed to an overall plan as developed either by the province or by a group of governments or industries collectively. That focus of attention at each hearing is resulting in the continual rejection of these applications and sites."

I have only one correction Ted - you might have said "in Canada and the United States."

Obtaining sites for new facilities is the single most difficult problem facing government and industry in regard to management of solid and hazardous wastes.

When the subject of wastes and their proper storage, treatment, recovery and disposal is discussed in generalities, there is agreement that these functions must be carried out in a manner so as to protect health and the environment and that strict government regulation is needed to assure that objective. But when the proposals become specific, that is to locate a specific facility on a particular site, most often the agreement evaporates and organized opposition forms very quickly. Technical, economic, social and political issues become inter-mixed, confused and unresolvable with the result that approval for use of the proposed site is not obtained.

The nature of the opposition to specific sitings is itself confused. Some opposition undoubtedly results from genuine fear of loss of property value or even bodily harm. There is every reason to believe however that much opposition results from a general attitude that the mere presence of a waste management facility in one's neighborhood or community somehow demeans a person to a form

of second class citizenship. And yet the opponents of specific waste management facility sitings can be equally strong in their demand for proper management of wastes. We are on the horns of a dilemma.

The problems of siting hazardous and non-hazardous solid waste management facilities have similarities and differences. Every community generates significant amounts of non-hazardous solid waste and every community must provide for its needs, whether through public or private entities. Every citizen uses the materials and goods that result in the production of hazardous wastes. Regional planning for solid waste management is often an economically efficient approach particularly if the solid waste management program includes new sanitary landfills or resource recovery facilities which have significant economies of scale.

But regionalization of solid waste management may exacerbate the siting problem. Who wants wastes disposed of in his neighborhood? What community wishes to be known as "the garbage capital" of the area?

Siting of hazardous wastes management facilities presents an even greater challenge. The need for such facilities is acute and yet the number required, particularly of off-site facilities, to service industries lacking their own capabilities, is much less than the required number of solid waste facilities. It appears that planning for hazardous waste management properly rests at the provincial level.

NSWMA believes that siting of solid and hazardous waste management facilities can best be accomplished if the siting effort is made a part of an overall program that includes a number of elements:

1. Enactment and enforcement of legislation to require environmentally sound management of wastes.
2. Promulgation of responsible regulations to implement that legislation and development of appropriate enforcement efforts. (Guidelines).
3. Planning for solid and hazardous waste management at regional and provincial levels.
4. Provision by statute of workable mechanisms to accomplish the siting of the needed facilities.

NSWMA believes that obtaining sites and maintaining them in operation requires that the public be fully informed and provided with ample opportunity to express their views.

NSWMA also believes that the public decisions regarding the waste management process including siting of facilities must be made by the persons best qualified to make those decisions.

To put these basic principles into practice, NSWMA recommends to the provinces a multi-step program for solid and hazardous management program development:

1. Legislation

Each province should enact legislation designed to assure the proper management of solid and hazardous wastes that are generated within the province. Provinces should require regional planning for solid waste management and province-wide planning for hazardous waste management. The legislation should recognize that movement of wastes across

jurisdictional boundaries may be a desirable and often necessary element of proper waste management practices. Existing institutions, including those in the private sector, should be recognized and considered in the legislation.

## 2. Regulations

Regulations should be promulgated at the provincial level to implement the legislation. The proper role of regulations is to assure that wastes are transported, stored, treated, received, disposed of in a manner so as to protect public health and the environment. Regulations for solid waste disposal should be designed to assure that all environmental laws are complied with, taking into account local conditions. Provinces must provide adequate resources to enforce these regulations so that the public is convinced that they are being properly protected.

## 3. Solid and Hazardous Waste Plans

The first step in the waste management program of a province or a region is the preparation of a plan. Planning by region is appropriate for solid waste management whereas hazardous waste management plans should be province-wide. The plan should accomplish the following:

- o Establish goals and objectives for prevention of adverse effects on the public health and on the environment resulting from improper waste collection, processing or disposal including protection of surface and groundwater quality, air quality, and the land.
- o Evaluate waste management needs by type and volume, including residential and commercial solid waste, hazardous waste, industrial sludges, pretreatment residues, municipal sewage sludge, air pollution control residue, and other wastes from industrial or

municipal sources.

- o Evaluate and select technically and economically feasible waste management options which for solid waste may include sanitary landfill, resource recovery systems, source separation or an adequate combination of these options. For hazardous wastes, the components of the management system may include storage, treatment (including incineration), recovery, deepwell injection, landfarming, secure land burial and any other appropriate options.
- o Develop an inventory and description of all existing operational facilities where waste is being treated, processed, disposed of, including a summary of the deficiencies, if any, of the facilities in meeting current waste management needs or complying with regulations. Identify the possible roles of existing facilities and sites in the overall waste management program.
- o Identify enforcement mechanisms for implementing the plan, including identification of the agency responsible for enforcement.
- o Provide current and projected population densities of each planning area and identification of population centers and centers of solid or hazardous waste generation.
- o Identify current and project future types of hazardous wastes generated by industry groups, location and quantity.
- o Identify areas in the planning region within which the required waste management facilities might be located, taking into account geological, hydrological and climatic conditions, access to trans-

portation, compatability of land use, existing zoning restrictions, and any other factors bearing on compliance with the provinces' waste management regulations and attainment of the goals of the plan.

- o Identify the role of interregional transport of solid waste and  
- interprovincial transport of hazardous wastes in the overall plan.  
Consider what role international transport might realistically play.
- o Provide a timetable for implementation of the plan.

In setting out the mandate for development of plans, the legislature should establish specific strict procedures and schedules for their drafting, review, public participation and comment, and final promulgation. The legislature should identify the agencies responsible for preparing the plans and designate an alternative if the primary agency fails to act.

The legislature should provide that future actions of public or private entities that are inconsistent with an approved plan may be held invalid.

#### 4. Technical Appraisal of Waste Management Facility Permit Applications

Upon application by a public or private entity for a permit to construct and operate a waste management facility the first step in the approval process should be a technical review by the appropriate provincial environmental regulatory agency. This review should determine whether the applicant has demonstrated that he will conform with all of the existing applicable waste management plans and regulations. Public comment should be encouraged during this phase of the review but should be limited to the questions of compliance with the plan and the environmental regulations.

Approval or denial of an application by the regulatory agency should constitute the final administrative review of the application regarding health and environmental factors.

Denial of an application at this step of the process should be based on specific findings that the application does not meet the established environmental regulations or plan and the details of these findings should be made part of the public record.

#### Social Appraisal of the Waste Management Facility Application

The province or region should provide a mechanism for social appraisal of the application after favorable environmental review. During this phase, subjective, non-quantifiable factors can be considered.

NSWMA recommends the establishment of a Siting Board to perform the social appraisal. Approval by a siting board constitutes final administrative approval of a permit application.

A Siting Board should consist of a broadly representative group of persons including both permanent and ad hoc members. The membership should be constituted to avoid dominance by particular interest groups including the community in which the site is to be located.

The principal task of the Siting Board is to weigh the social and economic issues relative to the community in which the facility is to be located.

It should not reconsider whether or not the application conforms with the approved

waste management plan or with the environmental regulations. The Siting Board should consider the specific implications of the proposed facility on the planning region and the locality in which it is to be sited.

The legislature should instruct the Siting Board how it should consider local zoning or land use ordinances. The Board should have the ability to circumvent local legislative or administrative actions designed to prevent specific facility sitings.

A Board should be able either to override local zoning or land use ordinances outright or be instructed to consider the zoning classification in effect at the time the waste management plan was adopted.

The Siting Board review and decision is the final administration action of the permit application decision-making process.

The need for waste management planning in Canada is quite obvious from two of the other articles in the same issue of Civic Public Works that I quoted from earlier. Quoting from Mr. K. J. Simpson, Head of the Waste Management Branch, of the Alberta Environment.

"There would be no objection to bringing wastes into Alberta for destruction, neutralization, detoxification or similar processing... But Alberta will generally not agree to importing wastes from out-of-province sources for purposes of storage or landfilling. Alberta has no intention of becoming the dumping ground for North America's non-putrescible wastes."



I take it from that excerpt that Alberta will not accept materials from other provinces or countries for disposal in a secure landfill. Such actions may be understandable - Simpson considers this "ultimately reasonable." But I hope that Alberta plans to provide the disposal facilities for whatever wastes are generated within its borders because the stated policy invites reciprocal action on the part of its neighbors.

In complete contrast, British Columbia's waste management "plan" if I can so interpret the remarks attributed to Mr. L. T. Hubbard, of the Pollution Control Branch, Province of British Columbia, seems to be:

"The main disposal option presently available to industry and the government in British Columbia is the service of Chem-Nuclear Systems, Inc., which operates hazardous wastes secure landfill in Arlington, Oregon. British Columbia enjoys a good working relationship with Chem-Nuclear and the State of Oregon and does not anticipate any closure of this disposal option."

NSWMA endorses waste management plans that take advantage of shipment of wastes across political boundaries when that lends to greater efficiency and protection of the environment. We would caution any governmental agency to be very aware of the political realities of such situations. Suppose there were to be a spill of a hazardous material in British Columbia that made headlines across the continent. Would Oregon be able to accept those wastes without jeopardizing the present arrangement? Probably not! This is but one of the precautions necessary to sustain waste management plans involving multiple political jurisdictions.

Transportation of Dangerous Goods in Canada  
by  
J.M. Gaudreau, Chief of Operations Division  
for Transportation of Dangerous Goods,  
Transport Canada, Ottawa

There is an increasing public awareness about the quantity of dangerous goods being transported throughout Canada.

Part of the reason for this is the amount of publicity which accidents involving dangerous goods have received.

Such incidents occur with a regularity that would be almost monotonous were it not for the danger to life and property and the risk of environmental damage they represent.

In 1977, in the United States alone, such accidents resulted in 32 deaths and 543 injuries.

The worst cases during this period were accidents involving gasoline and liquified petroleum gas (propane, butane) which caused 26 deaths and 102 injuries, followed by ammonia and chlorine accidents resulting in five deaths and 125 injuries. Accidents involving bromine and sulphuric acid, although causing no deaths, resulted in 301 injuries.

Statistics on similar accidents which have occurred in Canada are not available, but it is fairly safe to assume that there were fewer incidents and consequently less damage.

Why should we then risk impeding trade by introducing tighter regulations on the transporting of dangerous goods?

There seems to be only two possible responses to questions like this one. "How many people have to be killed or injured before something is done to rationalize and standardize regulations?" and "To what extent can a cost-benefit analysis be applied where human life is involved?".

Fortunately the majority of manufacturers, shippers and carriers of dangerous goods are quite willing to assist government in consolidating and developing comprehensive legislation in this field.

Behind their support is the realization that it is both costly and time consuming for them to ascertain and comply with existing national or international regulations where inter-modal transport is involved.

The carriers and emergency response personnel support the proposed new legislation because they see it resulting in enhanced safety for all concerned.

Safety is one of the prime concerns of the Transportation of Dangerous Goods Branch.

Branch objectives are:

- \* To promote the safe transport of substances posing inherent dangers to the transportation worker, transport equipment, the general public, and the environment.
- \* To facilitate the flow of dangerous goods through the transportation system by minimizing the differences in the regulations applicable in the various modes of transport and in the pre and post transportation phase of the commercial cycle.
- \* To co-ordinate governmental activities respecting the regulation of dangerous goods in the pre-post-and transport phases of the commercial cycle in order that the resources required to achieve safe transportation conditions can be minimized.

#### POTENTIAL PROBLEM

The Dangerous Goods Branch was established after a survey of existing legislation relating to dangerous goods indicated a serious potential problem.

The survey revealed that some 20 federal departments and agencies were involved in regulating the handling or transportation of dangerous goods in Canada. Within Transport Canada alone three types of international regulations exist.

The federal government set up a study group to examine the situation and recommend lines of action.

It was after this group met with representatives from some 20 federal departments and agencies, as well as representatives from the provincial governments, that it became apparent that a national code of regulations for the transportation of dangerous goods was necessary.

The Transport of Dangerous Goods Branch has four major responsibilities:

- 1) To prepare a multimodal, international and interprovincial code of regulations for the transport and transport-related handling of dangerous goods.

- 2) To develop an inspection service at multimodal transfer points, and at the plants of shippers and manufacturers, with modal inspection groups continuing to be responsible for the inspection within their own mode.
- 3) To provide training services in the field of transporting dangerous goods. These services may take the form of preparing and giving educational programs directed primarily at modal and multimodal inspectors, and emergency response personnel such as police and firefighters, and are to be incorporated into Emergency Planning Canada or emergency measures organizations programs across Canada. Awareness and training programs may eventually be developed for industry, and for the public at large.
- 4) To establish an Information and Emergency Centre to assist in providing information for industry, inspectors, emergency units and, where necessary, those federal or provincial organizations requiring such service. This Centre will operate 24-hours, seven days a week, starting in the early spring of 1979.

The service will be available throughout Canada via a toll-free telephone access number.

The centre will be equipped with conference lines permitting communications to be established directly between the response unit on the scene of an accident and whichever organization can provide the best advice.

#### RESPONSE MANUAL

An Emergency Response Manual will be published about the same time the centre opens. This manual will provide a numerical and alphabetical list of dangerous goods, along with their primary and secondary risks, an action code for firefighters, and product data sheets on what to do in the case of a fire or spills and an immediate first aid response.

The proposed multimodal, international and intergovernmental code of regulations can be subdivided into three main sections.

The first section provides regulations on the classification, packaging groups, compatibility and quantity limitations of dangerous goods or their means of transportation.

This section also prescribes responsibilities of the package manufacturer, the shipper, the carriers (air, rail, road and sea), the consignee as well as those transport facilities such as bridges, tunnels, and transfer points.

The second section is made up of a list of dangerous goods and schedules in which guidelines are established for the safe packaging, stowage and movement of these goods. This section takes into consideration the various modes of transport.

The packaging standards form the last section. This section outlines the appropriate construction standards for packages, containers and means of transportation such as cargo tanks, portable tanks and tank cars.

#### U.N. CLASSIFICATION SYSTEM

The foundation of all proposed placarding and labelling regulations is the comprehensive classification system developed by the United Nations which encompasses all dangerous goods.

This system identifies the following nine classes:

Class 1: Explosives

Class 2: Gases (Inflammable, Non-inflammable, Poison)

Class 3: Inflammable Liquids

Class 4: Inflammable solids, goods capable of spontaneous combustion and materials which will react to water

Class 5: Oxidizing materials and organic peroxides

Class 6: Poisonous and Infectious substances

Class 7: Radioactive Materials

Class 8: Corrosives

Class 9: Which includes those goods that don't fit into any other class and appear not to be dangerous, but none the less present certain hazards to the workers or to the mode of transport.

Perpetual Care for Waste Management Facilities  
by  
W. Williamson, Manager, Waste Utilization Section  
Waste Management Branch, Environment Ontario

The requirements imposed under the Environmental Protection Act on the location and operation of a landfill disposal site, and other waste management facilities, ensure that public health and safety concerns are met, and that minimal off-site contamination results.

However, there is public concern that despite all precautions, problems could still arise, due to inadequate operation, unforeseen contingencies, and accidents, both during the lifetime of the site and in the long term, perhaps many years after the site has ceased to be used.

This concern is particularly acute in the case of hazardous waste disposal sites, but it is also expressed as a reason for opposition to disposal sites for non-hazardous waste.

The Ministry of the Environment acknowledges the importance of these concerns and a Task Force has been set up within the Ministry to examine this entire question, on the basic premise that in order to fully protect the environment, the individual, and those sectors of public and private enterprise who are involved in waste management an assured source of funding is necessary in three major sectors:-

1. During operation, closure, and for subsequent monitoring and maintenance;
2. To provide off-site protection for third parties;
3. For "perpetual care" and for contingencies not covered by other measures.

The work of the Task Force to date is reviewed and its general conclusions described.

NOTE: See Task Force Report - Page 329.

## SESSION V

### CHAIRMAN



**C. E. McIntyre**

Director Northeast Region,  
Ontario Ministry of the Environment  
Sudbury, Ontario



**Removal of Heavy Metals from Tailings  
Recycle Water at Mattabi Mines Ltd.**

R. Bourke, Project Engineer  
Mattabi Mines Ltd., Ignace, Ontario

D. Kemp, Design Engineer  
Engineered Products and Systems  
Power Plant Supply Company  
Division of F. Hopkins Limited, Oakville, Ont.



**Waste Water Management Strategy for a  
Manufacturer of Halogenated Organic  
Chemicals**

G. Campbell, Manager, Process Technology  
Hydrosience, Inc., Westwood, New Jersey

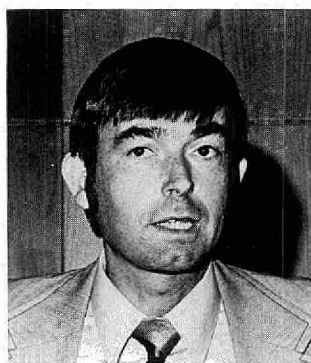


**Coal Ash Management in Ontario Hydro**

J. H. P. Buckingham  
Ash Management Supervisor  
Ontario Hydro, Toronto

**Performance Report on a New Heavy  
Metals Removal System via Sulfide  
Precipitation**

S. R. Korchin  
Market Specialist  
The Permutit Company Inc.  
Paramus, New Jersey



**Introducing the TAGA 3000**

Dr. N. M. Reid  
Vice-President, Research & Development  
Sciex Inc.  
Thornhill, Ontario

THE DEVELOPMENT OF A COMPREHENSIVE WASTEWATER  
MANAGEMENT STRATEGY FOR A MANUFACTURER OF  
HALOGENATED ORGANIC CHEMICALS

By

George R. Campbell  
Manager, Process Technology  
Hydroscience, Inc.

Jurgen H. Exner  
Senior Environmental Specialist  
Hydroscience, Inc.

and

Robert F. Ortleb  
Vice President  
Manufacturing and Engineering  
Saytech, Inc.



Saytech, Incorporated, a producer of specialty chemicals, operates a manufacturing facility in Sayreville, New Jersey. This plant, which was formerly operated by Hexcel Fine Organics, has been engaged primarily in the production of brominated organic chemicals. Until the end of 1976, the major products of the Sayreville plant were decabromobiphenyl (DBBP) and decabromobiphenyl oxide (DBBPO). Both of these chemicals have been used primarily as flame retardant additives in synthetic fibers and thermoplastics. The production of DBBP was discontinued in 1977, in favor of DBBPO, which is believed to be environmentally more acceptable.

In 1977, a nationwide survey of manufacturers of polybrominated aromatic chemicals was completed, under the auspices of the U.S. Environmental Protection Agency. The Hexcel facility was included in this survey, and the results revealed that certain areas of the plant site had become contaminated with trace amounts of DBBP. Acting upon this information, the New Jersey Department of Environmental Protection (NJDEP) initiated a series of site inspections and sampling surveys at the Sayreville plant. The NJDEP also found evidence of site contamination, and focused specific attention on the detection of polybrominated aromatics in samples of stormwater runoff, and the process discharge to the municipal sewer system. Concern was raised over the possibility of contamination of local groundwaters and surface waters, as well as the potential impact of process chemicals on municipal treatment plant operations. Following a meeting with plant personnel, the NJDEP entered into a consent agreement that directed the plant to institute immediate corrective actions and to implement a waste management program to prevent or control future releases of pollutants.

This paper traces the development of the comprehensive waste management program, as required by the consent agreement. Much of the work reported herein was executed by Hydrosience, Inc., in close cooperation with Saytech personnel.

While the program was necessarily directed to the resolution of the specific problems at the Sayreville site, it is believed that many elements of the waste management strategy have broad applicability throughout industry.

The situation that existed at the Sayreville plant in August 1977 may be visualized by referring to Figure 1, which is a schematic representation of the plant area. At that time, there were three major buildings on the site: an administration building containing offices, a maintenance shop, and a laboratory; the production building; and a warehouse. All chemical syntheses were undertaken in the production building. Chemical storage facilities were located between the warehouse and the production building, and consisted of a tank farm and drum storage area.

One of the unique features of the plant site is that it is located in an area having a high groundwater table. This geological characteristic gives rise to numerous springs and sources of surface drainage throughout the region. As shown in the figure, the plant is bounded on the north and south by two such drainage channels. In addition, there is a central source of surface drainage, which had been diverted through a 24-inch reinforced concrete pipe, at the time of plant construction. Stormwater runoff from the paved areas of the plant was directed to this pipe by a series of 6-inch or 8-inch laterals, as shown. All of these drainage channels, as well as the stormwater runoff, enter a pond at the western end of the plant property. The pond discharges to a creek that eventually joins the Raritan River. Essentially, the small surface streams and the pond became the focal point of the site contamination problem at the Sayreville plant.

The sampling survey conducted by the NJDEP indicated that contaminants were entering the pond by way of the 24-inch line and one or both of the other drainage channels. Some of these contaminants were conveyed by stormwater runoff from the plant area, while others were apparently entering the surface waters from upstream sources. In addition, the presence of brominated organics was detected in the process wastewater discharge to the municipal sewer system. These findings, supplemented by site inspections by NJDEP personnel, directly resulted in the negotiation of the consent agreement. The major elements of the consent agreement that are considered in this paper are summarized as follows:

1. Develop a program for the elimination of wastewater discharges to surface and groundwaters
2. Collect, contain, and properly dispose of chemical spillages
3. Modify surface drainage and runoff collection system to prevent contamination
4. Thoroughly characterize waste discharge to municipal system
5. Develop pretreatment system to remove chemicals that may impair the performance of the municipal treatment plant
6. Prepare updated spill prevention, control, and countermeasure (SPCC) plan

Obviously, the scope of the consent agreement required a multifaceted (and multidisciplinary) approach to the resolution of the problems at the Sayreville site. As in the case of any comprehensive waste management program, one of the first steps involved wastewater characterization to define existing conditions and provide the basis for the evaluation of control alternatives. Emphasis was placed on the collection and analysis of samples from the major discharge locations, namely the process effluent and the discharge from the 24-inch line. Supplemental samples were obtained at various steps in the production process, as well as from the inputs to the 24-inch line. Samples were analyzed for both general, nonspecific pollutional parameters (e.g., BOD, COD, SS) and specific organic constituents. The results of the sampling campaign will be presented in connection with the discussion of the major elements of the waste control program that follows.

One of the first areas to be addressed was the problem of contaminated stormwater runoff. As previously indicated, much of the site runoff was directed to the 24-inch pipe that runs through the center of the plant. The analysis of samples taken upstream and downstream of this pipe indicated a net increase in both organic and inorganic constituents, as evident from the following data:

|                        | 24-Inch Line                         |                                          |
|------------------------|--------------------------------------|------------------------------------------|
|                        | Upstream Inlet<br>(Surface Drainage) | Downstream Outlet<br>(Discharge to Pond) |
| COD, mg/l              | 13                                   | 55                                       |
| BOD, mg/l              | 1.3                                  | 7.9                                      |
| TOC, mg/l              | 4.0                                  | 23                                       |
| TDS, mg/l              | 83                                   | 187                                      |
| Cl <sup>-</sup> , mg/l | 14                                   | 37                                       |

Specific organic analyses, by GC/MS, revealed the presence of 69 to 109 mg/l of ethylene dichloride (EDC) in the downstream sample. EDC, a major chemical used in the production process, is commonly stored in the tank farm. Neither DBBP nor DBBPO were detected in the 24-inch line samples. Further analyses of other samples indicated that the principal source of EDC (435 mg/l) was the 8-inch lateral that traversed the drum storage and tank farm area.

A general strategy, based on probability of contamination, was adopted for the control of contaminated stormwaters. The total plant site was segmented into areas of high, intermediate, and low probability of contamination. The designation of each area was based on site inspection, reviews of operating procedures, and the results of the sampling campaign. The resulting area designations are displayed in Figure 2. The disposal concepts recommended for application to each area are summarized below:

| <u>Designated Area<br/>(Probability of<br/>Contamination)</u> | <u>Disposal Concept</u>                                                          |
|---------------------------------------------------------------|----------------------------------------------------------------------------------|
| High                                                          | Complete collection and containment disposal via pretreatment or offsite hauling |
| Intermediate                                                  | Containment and collection; regulated discharge to municipal sewer system        |
| Low                                                           | No containment or collection                                                     |

The materials storage (tank and drum) areas were assigned a "high contamination potential" classification. This is not to say that routine good housekeeping procedures will not be applied in these areas. Indeed, improved housekeeping measures formed an essential part of the overall final waste control program. However, these areas were recognized as potential sources of highly concentrated materials. The crushed rock bottom of the walled tank farm was replaced with an impermeable concrete base. The adjacent tank truck unloading area was excavated and enclosed with concrete curbs and base. The volume of the unloading area is sufficient to contain the "worst-case" spill of a full tank truck. Similarly, concrete curbs and an impermeable base have been constructed in the drum storage area. Each of these containment areas includes a collection sump, with pumps to facilitate the transfer of spills or contaminated stormwater to the pretreatment plant or to drums for offsite disposal.

The plant areas that are immediately adjacent to the production building, warehouse, and enclosed materials storage areas, received an "intermediate contamination potential" classification. Normal plant activities, such as the transfer of raw materials and products, can result in unavoidable spillages of small quantities of chemicals in this area. Again, the housekeeping practices that are included in a revised SPCC plan will minimize or correct such occurrences. Nevertheless, the containment and collection of stormwater runoff from the intermediate area will assure that no contaminants will enter surrounding waters. The implementation of this concept required several site modifications. First, the central surface drainage entering the property was diverted offsite via a newly constructed storm sewer. Second, the upper end of the 24-inch pipe was sealed, and other modifications were made to the onsite stormwater collection system. Third, a flow equalization basin was installed to contain and regulate the discharge of stormwaters to the municipal sewer system.

The balance of the plant site, including the employee parking lot and the roofs of the administration building and warehouse were designated as low contamination potential areas. Stormwaters from these locations will be permitted to run off to the surrounding area.

Another major element in the overall wastewater management program involved the development of a concept for controlling the discharge of potentially inhibitory or toxic chemicals to the municipal treatment system. Although there were no data to implicate the presence of DBBP with impaired efficiency of biological treatment processes, the NJDEP had specifically recommended a discharge limitation of 0.3 mg/l DBBP.

Analysis of the process effluent for nonspecific parameters revealed the following characteristics:

|                 | <u>Concentration, mg/l</u> |              |
|-----------------|----------------------------|--------------|
|                 | <u>Average</u>             | <u>Range</u> |
| COD             | 476                        | 296-650      |
| BOD             | 70                         | 43-104       |
| TOC             | 247                        | 179-366      |
| SS              | 124                        | 62-184       |
| TDS             | 7260                       | 6140-8010    |
| Cl <sup>-</sup> | 2450                       | 2220-2650    |
| pH (units)      | 11.8                       | -            |

In addition, specific organic analyses, using GC, GC/MS, and/or HPLC techniques indicated that the major organic components of the process discharge consisted of ethylene dichloride and DBBP. The following data were typical of the concentrations of these materials found in 24-hour composite samples of the process effluent:

| <u>Component</u> | <u>Concentration, mg/l</u> |              |
|------------------|----------------------------|--------------|
|                  | <u>Average</u>             | <u>Range</u> |
| EDC              | 1230                       | 684-2084     |
| DBBP             | 11.9                       | 3.6-23.4     |

In addition, other halogenated organics were detected or tentatively identified(\*) in the process discharge. These materials included:

DBBP (0.65 mg/l)  
 Lower brominated isomers of biphenyl oxide  
 (<1 to 20 mg/l)  
 Bromochloroethane (10-50 mg/l)  
 1,1,2 Trichloroethane (10-50 mg/l)\*  
 Trichloroethylene (10-50 mg/l)\*  
 Dichlorobromoethylene (10-50 mg/l)\*



Dibromoethane (1-10 mg/l)\*  
Bromodichloroethane (1-10 mg/l)\*  
Tetrachloroethylene (1-10 mg/l)\*  
Bromochloroethylene (1-10 mg/l)\*  
Dibromodichloroethylene (1-10 mg/l)\*  
Hexachloroethylene (1-10 mg/l)\*

The presence of a few of these compounds could be rationalized as products of side reactions of the production process. Many of the chemicals listed above, however, are recognized as impurities in the basic raw materials, e.g., EDC. This point serves to emphasize the fact that wastewater characteristics are often very subtly affected by the quality of the reactants used in organic syntheses.

It is important to note that the indicated levels of DBBP (and DBBP) were present entirely as particulate matter. Analyses of filtered samples revealed that water-soluble DBBP (and DBBP) concentrations were below detection limits (<50 µg/l). This observation was considered entirely consistent with the limited aqueous solubility of DBBP, which had been previously recognized, but not quantitatively defined. Indeed, the NJDEP's recommendation of an effluent limit of 0.3 mg/l of DBBP had apparently been based on an assumption or an estimation of the compound's solubility. The realization that the aqueous solubility of DBBP was apparently very low (<50 µg/l) was encouraging. It implied, for example, that a relatively straightforward pretreatment technique (e.g., filtration) could be developed to limit the discharge of solids (including DBBP). On the other hand, it was anticipated that more complex methods would be required to control the other major component, ethylene dichloride. The aqueous solubility of this material is reported to be approximately 8000-9000 mg/l. Although the NJDEP had not specifically cited EDC for control, this material has been listed as a priority pollutant by the USEPA. As such, it could be anticipated that EDC would be subject to future discharge and pretreatment regulations.

As a first step in the conceptualization of a pretreatment scheme, a comprehensive review of the production process was undertaken to obtain an understanding of the sources of waste generation. Operating procedures were examined to assess the potential for waste load reduction by source controls. The review was also conducted in the context of identifying opportunities for recycle or recovery of valuable process chemicals.

A schematic representation of the DBBPO production sequence is depicted in Figure 3. Basically, DBBPO is synthesized by reacting bromine with biphenyl oxide, in the presence of EDC. The off-gases from the reaction are captured in a caustic scrubber. The blowdown from the scrubber contains inorganic salts and entrained solvents. The reaction mixture is then neutralized, and centrifuged to recover the solid product (DBBPO). Vapors evolved during centrifugation are directed to a second scrubber that results in an aqueous discharge with characteristics similar to those of the main reactor scrubber effluent. During centrifugation, the solid product is washed with a water stream. Centrifugation mother liquors, as well as the washwaters and scrubber effluent are diverted to a phase separation tank that overflows to the main process sewer. Other process discharges arise from miscellaneous scrubbing operations, equipment cleaning, and spillage. In summary, the major sources of process wastewater may be listed as follows:

| <u>Source</u>                                                              | <u>Characteristics</u>                                 | <u>Flow Rate, gpd</u> |
|----------------------------------------------------------------------------|--------------------------------------------------------|-----------------------|
| Main Reactor Scrubber                                                      | EDC (1000 mg/l)<br>caustic                             | 20,000                |
| Separation Tank Effluent<br>(Centrifuge mother liquor, wash, and scrubber) | EDC (5000 mg/l)*<br>DBBPO (10 mg/l)*<br>other organics | 30,000                |
| Miscellaneous Sources<br>(Scrubbers, floor sumps)                          | EDC<br>DBBPO<br>other organics                         | 20,000                |

\* Aqueous phase concentrations

It is apparent that the separation tank effluent constituted the most significant source of process wastes. This tank was originally designed to function as a phase separation device. The liquid entering the tank typically consists of two phases: an EDC phase and an aqueous phase. Operating procedures called for EDC separation in the tank, and subsequent recovery by distillation. However, sampling and analysis of the tank overflow indicated that the tank was functioning poorly as a separation device. The overflow periodically



consisted of two phases, EDC and water. Since DBBPO (and DBBP) is preferentially soluble in EDC, the major source of these compounds in the process effluent is the inadvertant discharge of EDC that resulted from inefficient phase separation.

Having defined the major sources and characteristics of the process wastewaters, a preliminary evaluation of potentially applicable pretreatment schemes was then undertaken. The following unit operations were examined experimentally or theoretically for the treatment of DBBPO, DBBP, and EDC:

- Filtration
- Solvent extraction
- Solvent stripping
- Carbon adsorption
- Destructive oxidation

Destructive oxidation was rapidly eliminated from further consideration, because of the high organic load in the waste stream. The resulting preliminary conceptualization of process alternatives is displayed in Figure 4. As shown, each of the alternatives included a preliminary extraction and filtration step to remove the majority of brominated aromatics. EDC would then be removed either by stripping or by stripping with carbon polishing, or by carbon adsorption.

Laboratory-scale evaluations of carbon adsorption and stripping were performed to obtain performance data and develop preliminary design criteria. An engineering analysis was then undertaken to prepare cost estimates for each of the candidate processes. The results indicated that stripping of EDC followed by carbon polishing was the most expensive alternative, and would yield a waste stream of a quality similar to that produced by carbon adsorption alone. Carbon adsorption and stripping would require similar capital expenditures, but stripping would entail higher operating costs because of the high energy requirements.

The recommended process for the pretreatment of process wastes thus consisted of: (1) solvent (EDC) extraction of DBBPO, DBBP and other brominated aromatics; (2) filtration (5 $\mu$ ) of the aqueous layer for the removal of any remaining

particulate brominated aromatics; and (3) carbon adsorption for the removal of EDC and other trace halogenated organics. The process concept also included steam regeneration of the carbon, with EDC recovery. The recovered EDC would then be recycled to the extraction step, or to the production process.

It was envisioned that the extraction/filtration steps in the proposed pretreatment scheme could be readily implemented with relatively straightforward modifications to existing equipment. However, the adsorption process, including inplace nondestructive regeneration of carbon and EDC recovery, must be regarded as a rather novel concept, with limited prior application. Consequently, pilot plant investigations of this process were recommended to confirm laboratory-based performance estimates and to develop detailed design criteria.

Pilot plant studies were undertaken at the Saytech site over a 4-month period between April and August, 1978. The studies utilized a transportable skid-mounted adsorption/regeneration system provided by Hydrosience. The system had a nominal capacity of 1.6 gpm (8 gpm/sf). A granular activated carbon, Witcarb 950 (8 x 30 mesh), was used as the adsorbent. The system was evaluated on the effluent produced by the previously installed extraction/filtration step. A series of adsorption/regeneration cycles was imposed on the system. The results indicated that the overall process readily achieved the effluent objective of <0.3 mg/l DBBPO. In addition, the process produced an effluent that contained <10 mg/l EDP (>99% removal). It is the authors' intention to provide a more detailed presentation of the development of this process, including the pilot studies, in a future paper.

An overall summary of the wastewater management concepts that are being implemented by Saytech, Inc. is depicted in Figure 5. At the present time, most of the site modifications have been completed. The fullscale pretreatment process is currently in detailed design and is scheduled for construction and startup in late 1979. The projected capital cost for the pretreatment system (including extraction/filtration equipment modifications and the adsorption/regeneration process) is \$164,000. Net operating costs are expected to be approximately \$30,000 per year. This projected cost

includes a credit for the recovery of 650 pounds of EDC per day at a present value of 12 cents per pound. Overall, the total cost of the wastewater management program that was developed for the Saytech facility has been estimated at \$800,000.

In retrospect, the site contamination problems that developed at the Sayreville plant were, in reality, quite subtle and largely unrecognized prior to the findings of the EPA's national survey of manufacturers of brominated organics. And, in many respects, the solutions that are being implemented by Saytech are in advance of both the state-of-the-art and of Federal EPA requirements. Essentially, the NJDEP mandated the adoption of Best Management Practices (BMP's) for spill prevention and control even before the Federal Government had defined the meaning of BMP's. Similarly, the pretreatment process will have been placed in operation before Federal pretreatment standards are adopted.

Industry, as a whole, has come to appreciate that new environmental problems will continue to be identified as advances are made in analytical sensitivity and specificity, and as more information becomes available on the environmental effects of synthetic organic chemicals. Government, industry and consultants must be prepared to address these problems with new and innovative technologies, since classical approaches will not be sufficient to deal with the environmental issues of the future.

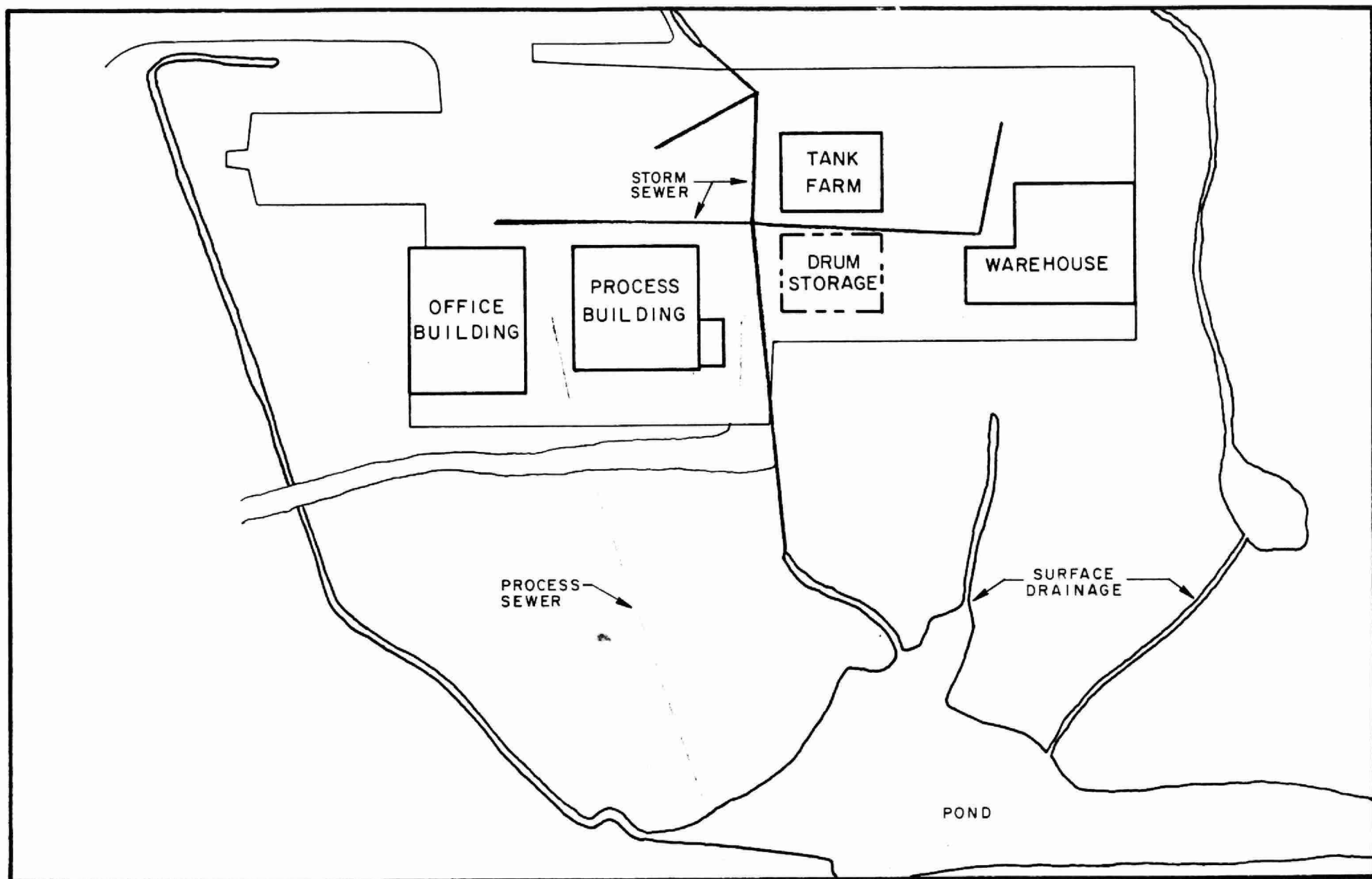


FIGURE I  
SCHEMATIC OF PLANT SITE

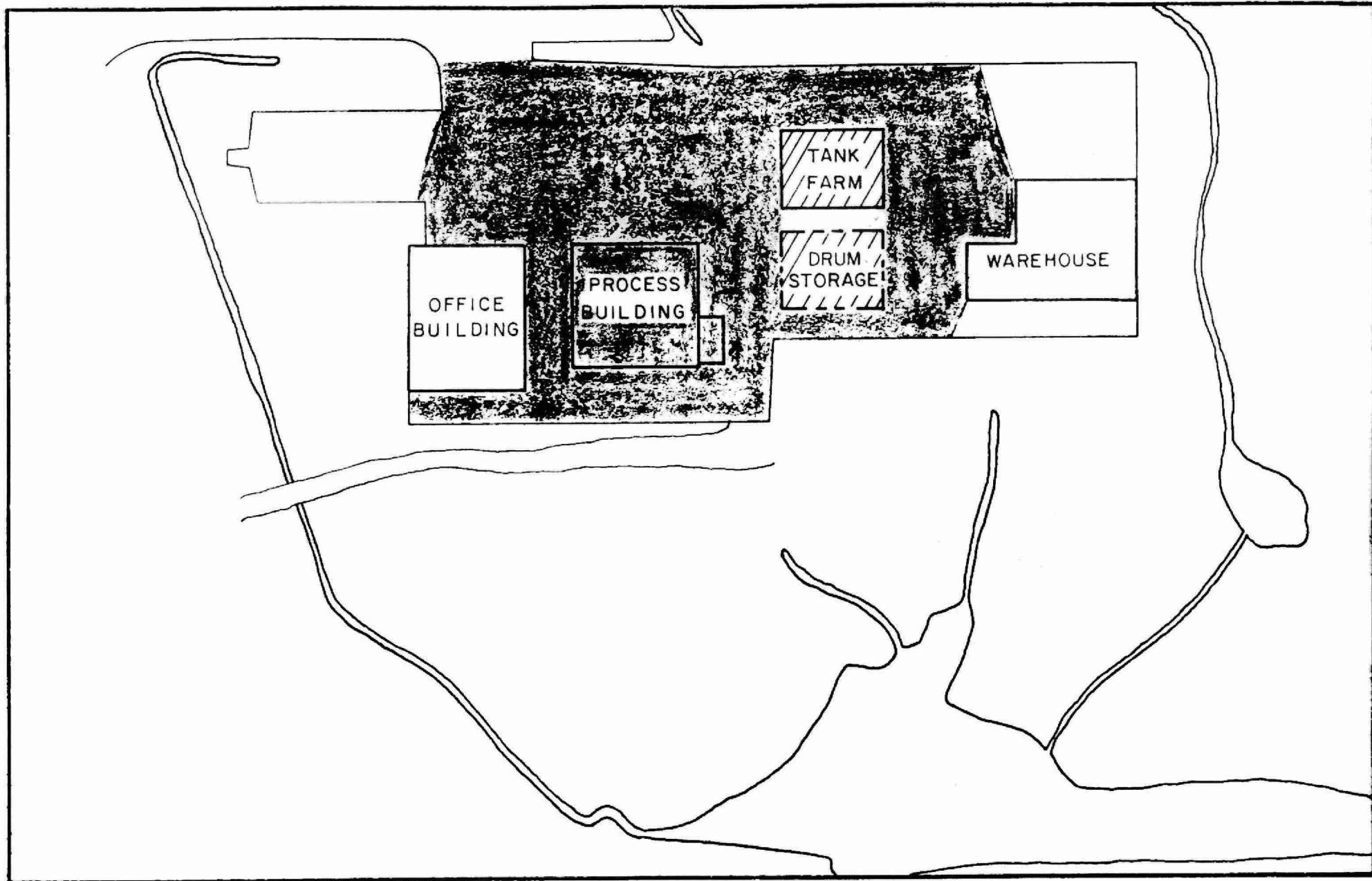


FIGURE 2  
CLASSIFICATION OF SITE RUNOFF

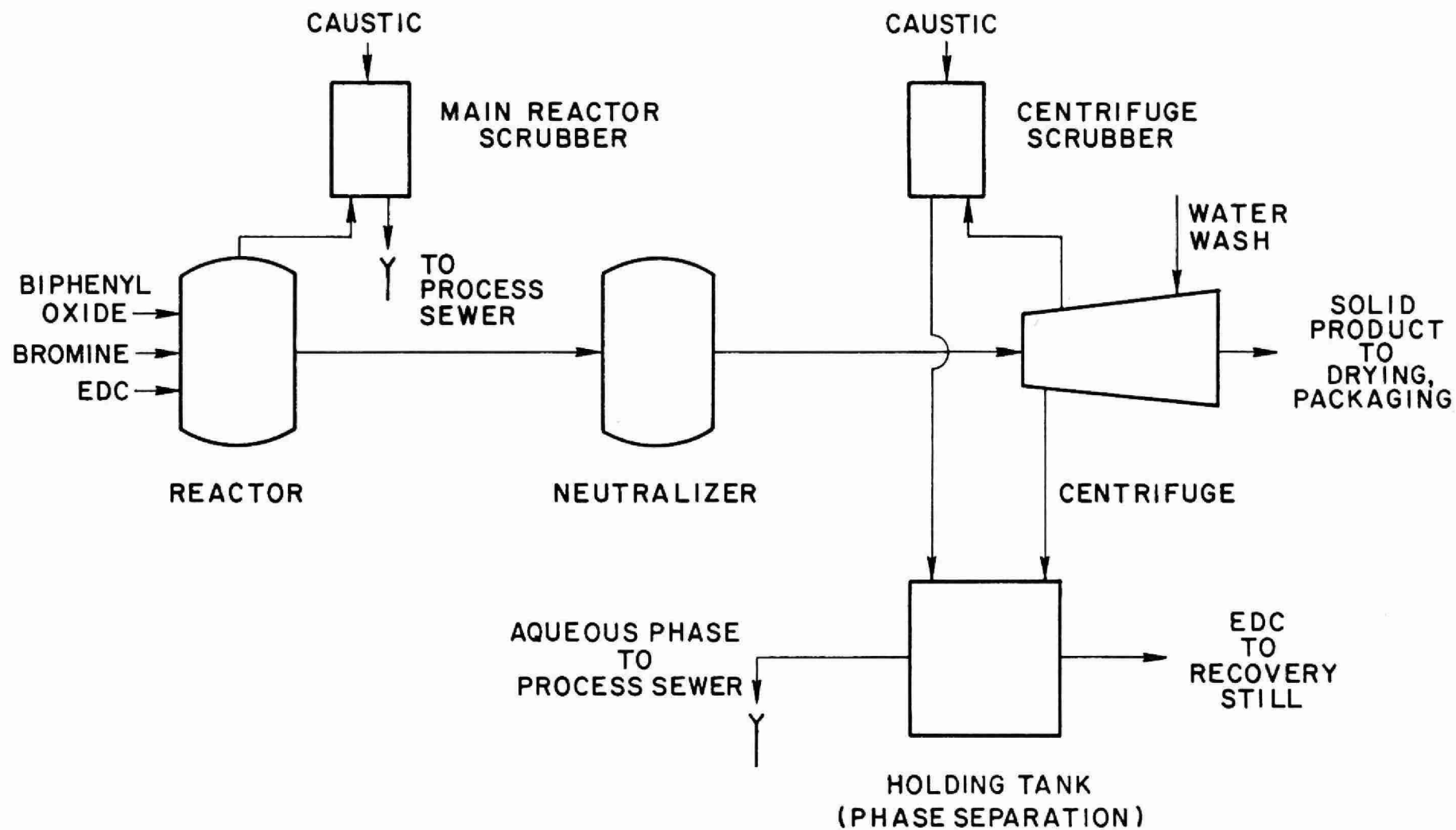


FIGURE 3

DBBPO PRODUCTION SEQUENCE

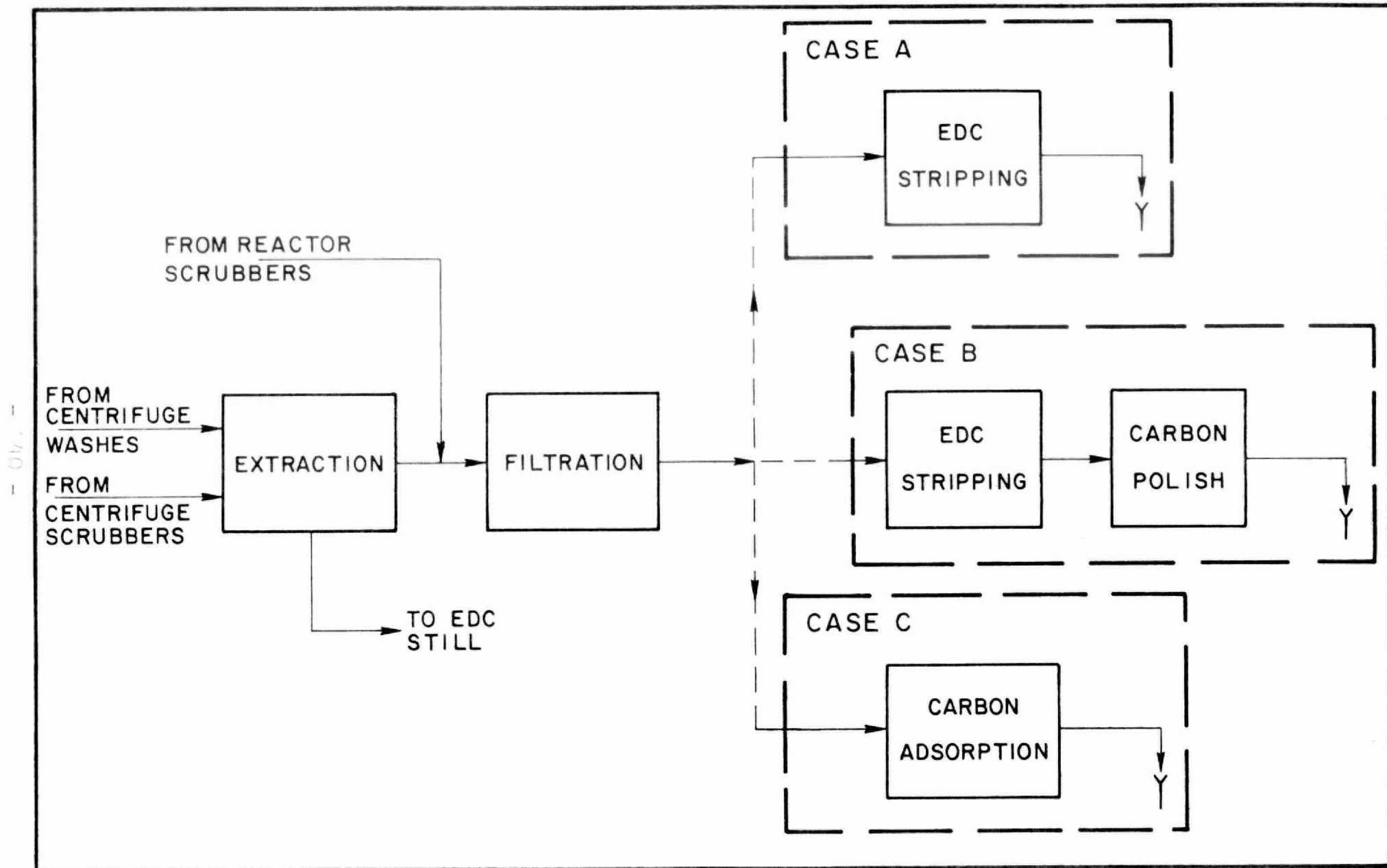


FIGURE 4

CONCEPTUAL FLOW DIAGRAM FOR PRETREATMENT PROCESS ALTERNATIVES

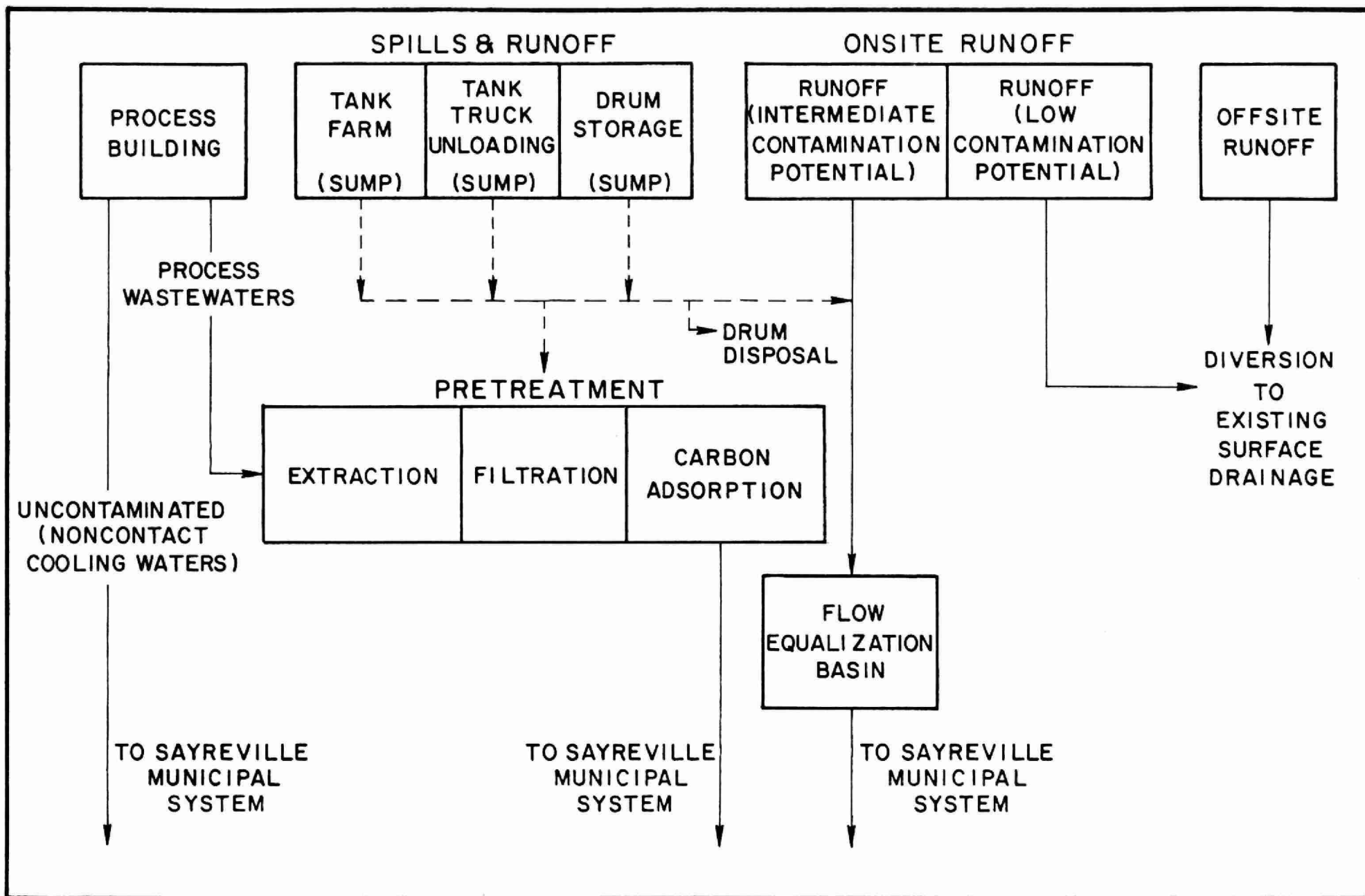


FIGURE 5

SCHEMATIC REPRESENTATION OF OVERALL WASTEWATER MANAGEMENT STRATEGY



# REMOVAL OF HEAVY METALS FROM TAILINGS RECYCLE WATER AT

## MATTABI MINES LIMITED

BY

R.D. BOURKE and F.D. KEMP

### Introduction

Over the past few years considerable attention has been given to the contamination of surface waters by heavy metals. Realizing a potential source of contamination from mine tailings seepage and abandoned mine drainage, the mining industry in Ontario has endeavored to keep abreast of current wastewater treatment technology and also develop their own treatment systems.

At the Mattabi Mines Ltd. lead-zinc-copper mine and mill at Sturgeon Lake, Ontario, a design committee consisting of mine metallurgists and environmental engineers, a Dutch research and development team, and the equipment suppliers engineering staff, worked together to develop a compact, cost-effective, and technically sound treatment process to remove heavy metals from the mine tailings overflow.

With the use of some new and innovative wastewater treatment equipment, the effluent quality is consistently meeting the guidelines established by the Ontario Ministry of the Environment. The sludge produced from the precipitated metals is sent directly to the concentrator, thus eliminating the danger of re-dissolving the metals in a landfill site, and recovering

some of the valuable metals that would otherwise be wasted in a sludge landfill.

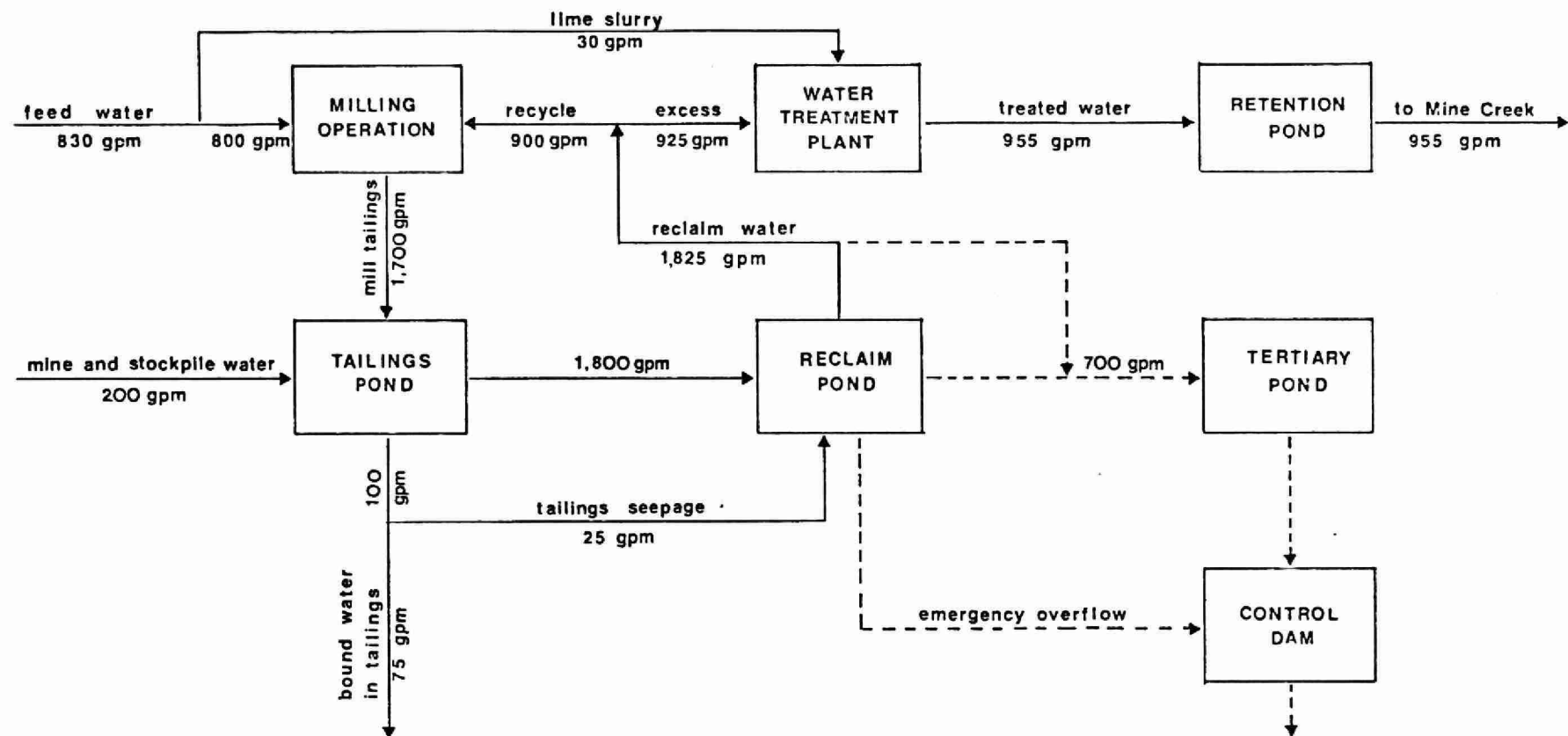
### Background

At the Mattabi Mines Ltd. facility, wastewater comes from two sources; the mill tailings, and the mine and stockpile water. As shown in figure 1, about half of this water is reclaimed and returned to meet the requirement of the milling operations. The other half, or excess tailings water, must be discharged. Over a period of four years, this tailings pond overflow was monitored for pH value and heavy metals concentrations. It was observed that during the summer months, even with the addition of large quantities of soda ash, the overflow from the tailings pond area frequently showed pH values of less than 5. Correspondingly high heavy metals concentrations were found to exist with these low pH values.

Substantial concentrations of dissolved heavy metals occur in mine waters that have become acidic. Acid mine waters are produced from the oxidation of metallic sulphide minerals, particularly those containing iron (1). Theoretically, this oxidation can occur either chemically or biologically. Differences of opinion exist as to the relative importance of these two oxidation pathways, however, there is considerable evidence which suggests that biological oxidation is significant, if not predominant.

The case of pyrite ( $\text{FeS}_2$ ) will illustrate the generation of acid mine water,





#### Legend

- continuous
- - -→ intermittent

Figure 1: MATTABI MINES WATER BALANCE

In theory, the complete oxidation of pyrite mineral produces two moles of sulphuric acid per mole of pyrite. Similar reactions describe the oxidation of other sulphide minerals. In practice, oxidation is not complete, and various quantities of reaction products in an intermediate oxidative state can be found, namely thiosalts.

It is this acid generation which results in the dissolution of heavy metals such as copper, lead, nickel and zinc. The extent of dissolution of these metals is based on their solubility at various pH values. Generally, as pH is lowered from the neutral point, the solubility of metals increases significantly. Therefore, the concentration of heavy metals in mine water is dependent on the pH value of the solution.

A typical analysis of the excess tailings water of Mattabi Mines Ltd. during the summer would show zinc, lead and copper as the primary heavy metal contaminants. The concentrations of these metals vary with the time of year, but generally they can be described in the following manner:

pH  
4.8

Cu  
0.03 mg/L

Pb  
0.09 mg/L

Zn  
10.0 mg/L

Fe  
1.90 mg/L

(This table is based on the average analysis of 41 consecutive daily composite samples taken during July and August 1978)

The result of the monitoring programme for the excess tailings water was that some form of treatment for the tailings pond overflow was required in addition to the neutralizing and ponding that was already being carried out.

At the outset it was decided that some form of mechanical treatment was necessary in order to provide continuous removal of the precipitated metals. With lime neutralization as the basic process, conventional clarification was investigated as a method for separating the precipitated heavy metals from the liquid phase. It was found that a conventional, circular clarifier could produce the required effluent quality.

Further pilot testing included the use of the Pielkenrood-Vinitex Tilttable Plate Separator (TPS). Using sludge recycle and polyelectrolyte addition, the TPS was found to be very efficient in removing residual heavy metals.

After evaluation of the two forms of separation it was decided that the TPS system was better suited to this treatment requirement. The following is a summary of the two forms of solids separation.

#### 1. Advantages of TPS

- (a) Flexibility - the modular design of the TPS system allows for partial shut-down of the system in order to meet varying influent flow conditions. Also, TPS units can be added after initial construction in order to accommodate higher flows in the future.
- (b) Short Residence Time - the short residence time through the whole system results in quick treatment stability, and lends itself to easy shutdown and start-up which may coincide with plant shutdowns, and routine maintenance shutdowns.

## 2. Advantages of Conventional Clarifier:

High Underflow Concentration - the Conventional circular clarifier with its inherently large thickening capacity can provide chemical sludges with near maximum suspended solids concentration.

## Disadvantages of Conventional Clarifier:

Outdoor Installation - the large size of these units necessitates outdoor installation, however, problems such as icing of overflow weirs, thermal density stratification and wind agitation, could occur.

## Design Process

The equipment design and selection was supervised by a team consisting of mine metallurgists and environmental engineers, a Dutch research and development team, and the equipment supplier's engineering staff. Distinct benefits were realized by taking advantage of the specialized knowledge that each of these groups could offer. Briefly,

- Mattabi Mines Ltd. and Noranda Mines Ltd. engineers and metallurgists have extensive knowledge of mineral processing technology and mine wastewater management.
- The Pielkenrood-Vinitex research team has years of experience in industrial wastewater treatment.
- The equipment supplier, Power Plant Supply Co., has specialized experience for equipment sizing, operation, instrumentation and control.

The combined efforts of the project management team resulted in a cost-effective treatment plant that would be operated by staff who had input into the original design.

The basic objectives of the design process are outlined in figure 2.

## Figure 2: OBJECTIVES OF WASTEWATER TREATMENT PLANT

A water treatment facility should treat the tailings area effluent at a rate of 1,000 igpm. The purposes of the water treatment process are to:

1. Neutralize the acidic tailings area discharge water,
2. Remove most of the heavy metal contaminants from this discharge water,
3. Provide a treated water that is low in suspended solids, and
4. Provide a concentrated sludge that can be handled for disposal.

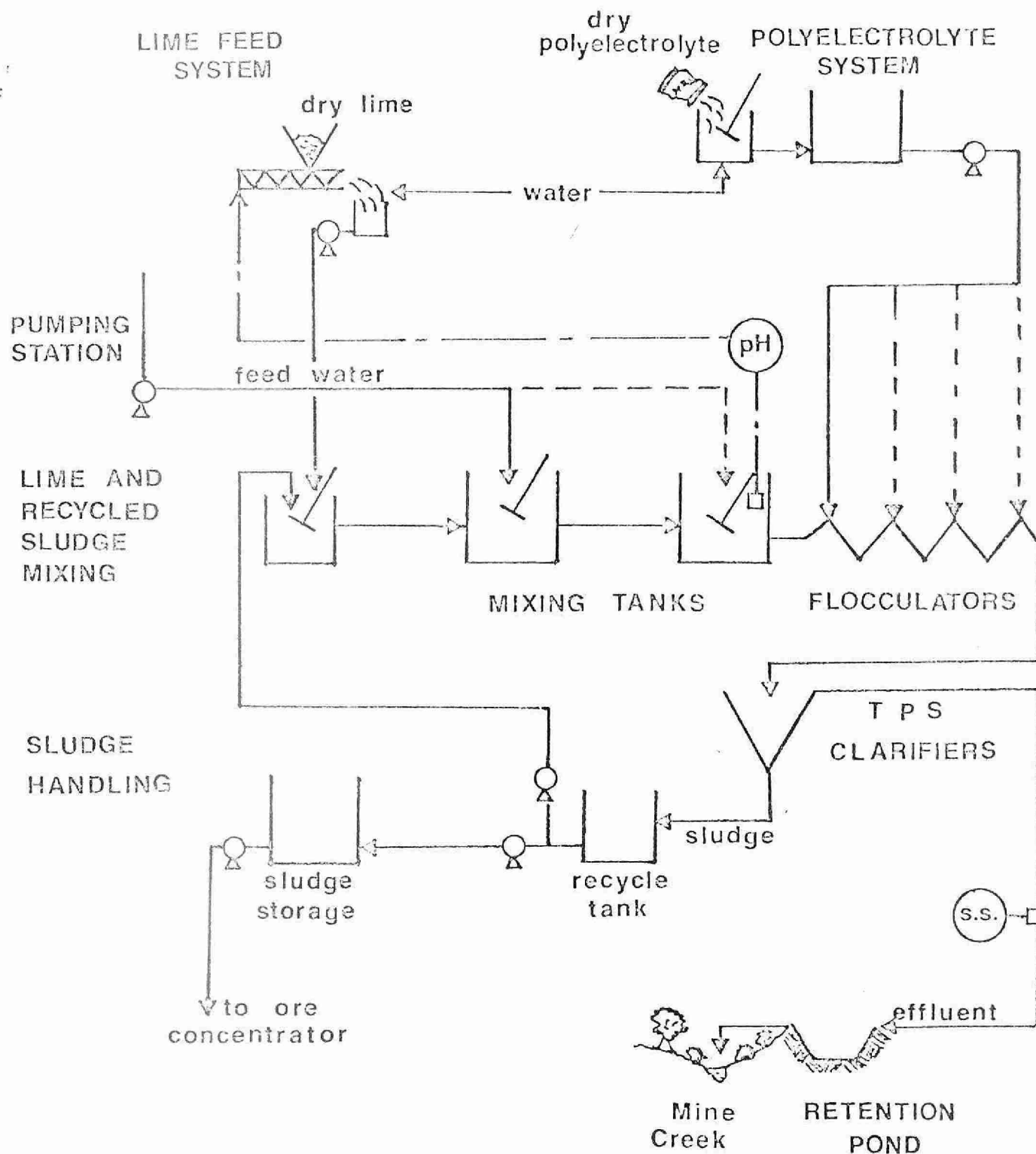


Figure 3: MATTABI MINES WATER TREATMENT PLANT



### The Treatment Plant

A Schematic diagram of the treatment plant is shown in Figure 3.

### Location

The treatment plant, excluding the lime and polyelectrolyte feeding systems, is located in a 54' x 56' x 24' high insulated building situated at the concentrator adjacent to the reagent storage and mixing area. The lime and polyelectrolyte feeding systems form part of the existing reagent area components.

### Pumping Station

The quantity of pretreated mine water that had previously been discharged to surface water is being put through the treatment plant.

It was found that the excess water from the tailings pond area amounted to about 1000 Igpm (273 m<sup>3</sup>/h). This flow was selected as the design flow rate. In order that this flow could be diverted through the treatment plant, the recycle line was extended to the treatment plant, and now the influent for neutralization is metered from this line.

The recycle water pumping station had to be upgraded to handle this additional flow.

### Lime Feed System

The treatment plant was located adjacent to the chemical storage facility so that the existing storage and metering system could be used to feed the neutralization plant. pH control is automatic with a closed-loop between the second reaction vessel and the dry lime feed pump. Prior to its introduction, the lime is made into slurry form. Lime consumption

varies with the season, but is a maximum of about 0.7 lb/1000 gal. (70 mg/L). The hydrated lime that is being used appears to be about 30% effective. The remaining bulk of the lime does not have any neutralizing capacity, possibly because of the short residence time in the system, inert coatings on lime crystals, and high concentrations of insoluble material.

#### Lime and Recycled Sludge Mixing

Recycled sludge has been found to significantly enhance the settling characteristics of heavy metal precipitate. Also, the recycled sludge particles may provide nuclei for calcium sulphate precipitation, thus eliminating the annoyance of equipment scaling. In this operation, the lime slurry and recycled sludge stream are combined in a reaction vessel which overflows into the first raw water mixing tank.

#### Mixing Tanks

Two completely stirred tank reactors (CSTR) in series are used to mix the lime and sludge with the raw wastewater influent. Experiments indicated that the use of two CSTR's in series provided the optimum reaction. The CSTR vessel provides insensitivity to pH change that is required for the pH-dependent reaction. By placing two CSTR's in series, the residence time distribution was compressed slightly. Thus a trade-off between insensitivity to pH change and reduced short-circuiting was affected.

The treatment process is operated with a pH value of about 10.0 in the second mixing tank.

### Polyelectrolyte Mixing and Feeding

Polyelectrolyte solution is prepared from powder on a batch-wise basis. From the initial mixing tank it is transferred to a feeding tank with two metering pumps, one for each flocculator. The solution is injected into the flocculators by way of specially designed injectors that can be removed without interrupting the main stream. Pulsing from the positive displacement metering pumps is eliminated by injecting through a diaphragm which opens at 20 - 30 psig (140-210 KPa). The polyelectrolyte dosage is generally about 0.0065 lb/1000 gal. (0.65 mg/L).

### Flocculators

Two pipe flocculators are used in this treatment plant. Starting from fundamental research Pielkenrood-Vinitex developed this compact flocculator. One of the most important features of this unit is its narrow residence time distribution which approaches the theoretically attainable distribution. Research by others using polyelectrolytes indicates that the narrowest residence time distribution results in the best flocculation of heavy metal precipitates (2). Because energy is very evenly introduced, a narrow distribution in the velocity gradient (G-value) is obtained, causing the flocs to build up rapidly and show remarkable uniformity in size, form, and structure. As a result, the suspension has rapid and uniform settling properties that improve clarity of overflow and sludge thickening.

### TPS Clarifiers

High rate Pielkenrood-Vinitex TPS clarifiers are used to separate

the flocculated heavy metal precipitate from the neutralized liquid phase. Eight TPS corrugated plate packs are placed in two separate tanks. Space is provided for the addition of up to four more plate packs, thus increasing the overall capacity by 50%.

Clarifier underflow is about 4 to 6% suspended solids. It is believed that the only limitation to a higher sludge concentration is the depth of the hoppers below the plate packs. Height-of-building constraints required the use of shallower than normal hoppers. An optimum balance had been established between building cost and sludge underflow concentration.

#### Sludge Handling

Sludge that is collected in the clarifiers is either recycled or wasted as excess sludge. These sequences are automatically controlled through a central control and sequencing panel, therefore, continuous supervision is not required. The excess sludge is placed in storage vessels that also act as thickeners. The thickened sludge is pumped directly to the ore concentrator and the supernatant is returned to the head of the treatment process.

#### Retention Pond

As a contingency for possible treatment plant failures, a pond with twenty-four hour retention at 1000 Igpm ( $273 \text{ m}^3/\text{h}$ ) is provided following the TPS clarifiers. During normal operation, the TPS clarifies the wastewater to such an extent (turbidity = 0.5 to 0.9 NTU) that the TPS effluent and the retention pond effluent are identical (within analytical error).

## Operation

The basic operating principles of the water treatment plant are outlined as follows:

- 1) Lime slurry is added to the contaminated water to bring the pH to about 10 so that the heavy metals will precipitate in the form of hydroxides.
- 2) Large tanks with mixers allow the chemical precipitation to occur during an average of 20 minutes contact time.
- 3) Polyelectrolyte (anionic) solution at a concentration of about 0.17% is added to the metal hydroxide suspension in order to aid in the flocculation of dispersed particles.
- 4) The flocculated stream is fed to clarifiers that contain a "pre-settling" chamber for the more dense particles that resist settling. The polishing chamber consists of a number of vertically stacked parallel plates that are corrugated and placed at a vertical angle of 60°, in order to aid in the removal of small slow-settling solids.
- 5) Approximately 90% of the collected metal hydroxide sludge is recycled to the contact tanks to keep sufficient solids in the system for optimum flocculation and settling.
- 6) The remaining 10% of the sludge is pumped to excess sludge storage tanks from which it can be disposed periodically.
- 7) Disposal consists of filtering and drying the sludge for shipment as zinc concentrate.

### Control System Features

- 1) Line feed system - the feed rate is automatically adjusted according to a signal from the pH analyser in the second mixing tank.
- 2) The treatment plant influent is stopped automatically under any of the following conditions:
  - high level in the recycle tank
  - low level in the recycle tank
  - recycle pump failure
  - high effluent turbidity
- 3) The clarifier underflow control valves close automatically if the influent flow stops, or if the recycle tank high level alarm is activated.
- 4) All of the treatment plant pumps stop automatically when the influent flow stops.
- 5) Remote alarms are activated in the concentrator control room for any of the following reasons:
  - high pH in second mixing tank
  - high sludge level in excess sludge storage tanks
  - high level in mixing tanks
  - high level in sump

### Operational Problems

The 3" and 6" diameter butterfly valves that control clarifier underflow

leak both internally (around the disc) and externally (around the operator shaft). The internal leak upsets the underflow balance among the four hoppers. Hoppers with valves that leak will gradually lose sludge, while the other hoppers will build up more sludge than they should. The external leaks are messy, and ruin the appearance of the water treatment plant.

The abrasive nature of the underflow sludge has caused considerable problems with the original recycle pump. Because an estimated 70 - 85% of the hydrated lime that is used for neutralization is insoluble quick lime and silica sand, it is understandable that a pump with substantial resistance to abrasion must be used. To meet this demand the original pump, a MOYNO progressing cavity model, was replaced by a rubber - lined slurry pump.

The importance of reaction suspended solids concentration (S.S. in mixing tanks) is illustrated in figure 4. Although maintaining a high S.S. concentration (0.50 to 0.75%) seems critical to efficient operation of the treatment plant, a monitoring device has not been installed as yet. Manual analysis is used at the present time.

### Results

The treatment plant began to operate in June 1978. Since this start-up time, the plant has shown a gradual increase in effectiveness. With a few exceptions, the guidelines of the Ontario Ministry of the Environment (M.O.E.), of less than 1 mg/L combined copper, lead, nickel and zinc, and pH in the range 5.5 to 10.5, have been met.

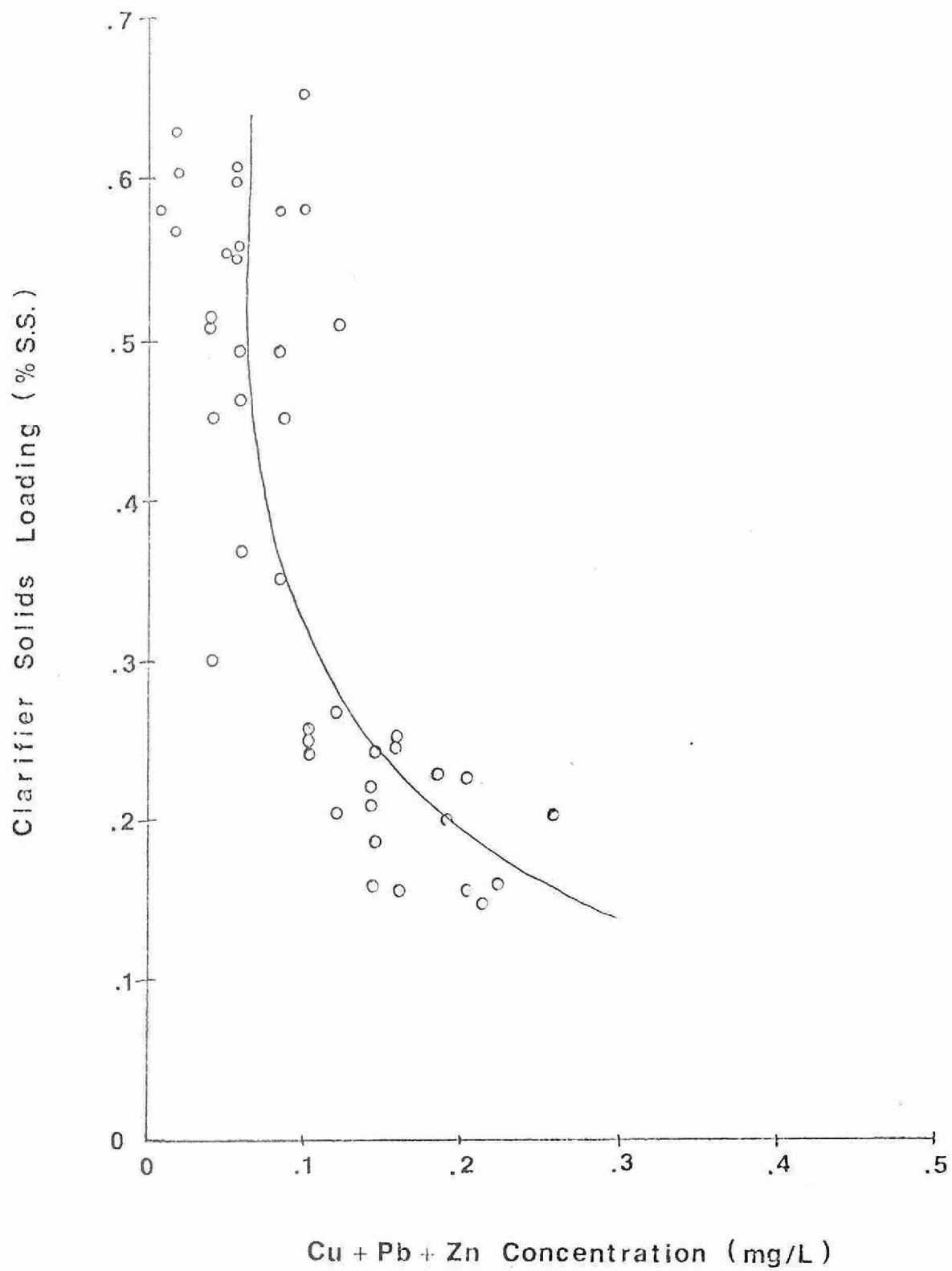


Figure 4: CLARIFIER LOADING vs EFFLUENT QUALITY



A summary of the treatment plant effectiveness for removal of heavy metal contaminants is presented in tables I and II. The only months that showed heavy metals above the M.O.E. guidelines were June 1978, at start-up, and October 1978, when problems with the recycle sludge pump were experienced. During October the recycle pump was showing signs of severe wear to the internal parts. Finally, the design recycle rate could not be provided. There was a decrease in the effectiveness of the removal process as a result. When the recycle rate could be returned to normal, the removal efficiency went back to an acceptable level.

Close examination of the recycled sludge and the original recycle pump indicated that the progressing cavity type was not well-suited to the type of sludge being produced. Table III shows that the sludge can contain as much as 2.92%  $\text{SiO}_2$  (silica sand), and up to 37.1%  $\text{CaO}$  (quick lime). This makes the sludge very abrasive to handle. The rubber-lined slurry pump appears to be better at recycling the abrasive sludge.

Table I: WATER TREATMENT PLANT INFLUENT QUALITY  
(RECLAIM POND EFFLUENT)

note: concentrations expressed in mg/L

|             | <u>pH</u> | <u>Cu</u> | <u>Fe</u> | <u>Pb</u> | <u>Zn</u> | <u>SO<sub>4</sub><sup>-</sup></u> | <u>S<sub>2</sub>O<sub>3</sub><sup>-</sup></u> | <u>total *<br/>metals</u> |
|-------------|-----------|-----------|-----------|-----------|-----------|-----------------------------------|-----------------------------------------------|---------------------------|
| spring 1978 | 6.1       | 0.10      | 4.52      | 0.06      | 6.82      | 715                               | 72.0                                          | 11.5                      |
| summer 1978 | 6.0       | 0.08      | 1.19      | 0.10      | 9.82      | 764                               | 5.5                                           | 11.2                      |
| fall 1978   | 6.2       | 0.03      | 1.59      | 0.09      | 9.70      | 779                               | 22.5                                          | 11.4                      |
| winter 1979 | 6.5       | 0.02      | 2.32      | 0.06      | 6.02      | 848                               | 35.9                                          | 8.42                      |

\* Cu, Fe, Pb, Zn.

**Table II: WATER TREATMENT PLANT EFFLUENT QUALITY  
(RETENTION POND INFLUENT)**

note: concentrations expressed in mg/L

|                          | <u>pH</u> | <u>Cu</u> | <u>Fe</u> | <u>Pb</u> | <u>Zn</u> | <u>total *</u><br><u>metals</u> |
|--------------------------|-----------|-----------|-----------|-----------|-----------|---------------------------------|
| <b>1978</b>              |           |           |           |           |           |                                 |
| <b>JUNE<sup>1</sup></b>  | 9.9       | 0.01      | 0.28      | 0.02      | 1.25      | 1.56                            |
| <b>JULY</b>              | 9.7       | 0.01      | 0.10      | 0.02      | 0.39      | 0.52                            |
| <b>AUG.</b>              | 9.7       | <0.01     | 0.05      | <0.01     | 0.35      | 0.40                            |
| <b>SEPT.<sup>2</sup></b> | 9.9       | <0.01     | 0.07      | <0.01     | 0.56      | 0.63                            |
| <b>OCT.<sup>3</sup></b>  | 9.9       | <0.01     | 0.07      | 0.01      | 1.10      | 1.18                            |
| <b>NOV.</b>              | 9.9       | <0.01     | 0.08      | <0.01     | 0.86      | 0.94                            |
| <b>DEC.<sup>4</sup></b>  | 10.0      | <0.01     | 0.04      | <0.01     | 0.23      | 0.27                            |
| <b>1979</b>              |           |           |           |           |           |                                 |
| <b>JAN.</b>              | 10.0      | <0.01     | 0.02      | <0.01     | 0.16      | 0.19                            |
| <b>FEB.</b>              | 10.0      | <0.01     | 0.03      | 0.01      | 0.06      | 0.09                            |

<sup>1</sup> start up

<sup>2</sup> sludge valves started leaking

<sup>3</sup> valves cont'd to leak; recycle pump capacity falling

<sup>4</sup> valves rebuilt; new recycle pump installed

\* Cu, Fe, Pb, Zn.

Table III: WATER TREATMENT PLANT SLUDGE CHARACTERISTICS (% w/w dry)

| <u>sample</u> | <u>sludge<br/>S.S.</u> | <u>Cu</u> | <u>Fe</u> | <u>Pb</u> | <u>Zn</u> | <u>CaO</u> | <u>MgO</u> | <u>Mn</u> | <u>SiO<sub>2</sub></u> |
|---------------|------------------------|-----------|-----------|-----------|-----------|------------|------------|-----------|------------------------|
| 1978          |                        |           |           |           |           |            |            |           |                        |
| summer        | -                      | 0.22      | 3.68      | 0.35      | 18.2      | 9.60       | 11.2       | -         | -                      |
| fall          | -                      | 0.20      | 3.52      | 0.24      | 20.8      | 13.8       | 7.50       | -         | -                      |
| 1979          |                        |           |           |           |           |            |            |           |                        |
| winter        | 3.5                    | 0.05      | 3.30      | 0.17      | 21.6      | 13.6       | 7.50       | -         | -                      |
| spring        | -                      | 0.13      | 8.90      | 0.04      | 8.8       | 37.1       | 3.40       | 1.20      | 2.92                   |

### Costs

A summary of the capital cost of the treatment facility is shown below:

|                                                                     |              |
|---------------------------------------------------------------------|--------------|
| Steel building with concrete foundation                             | \$110,922.00 |
| Process Equipment and installation                                  | 380,916.00   |
| Retention pond and other outside construction                       | 58,000.00    |
| Electrical construction, additional instrumentation,<br>and heating | 32,265.00    |
| Subtotal                                                            | 582,103.00   |
| Engineering                                                         | 21,000.00    |
| Total Capital Cost                                                  | \$603,103.00 |

The following is a summary of the operating cost for the treatment facility for each 1,000 lgal (273 m<sup>3</sup>/L):

|                                          |         |
|------------------------------------------|---------|
| Chemical Cost - hydrated lime at 66 mg/L | \$0.026 |
| - polyelectrolyte at 0.65 mg/L           | 0.011   |
| Utilities                                | 0.017   |
| Labour - at 1h/day, 5 days/wk.           | 0.003   |
| Cost per 1,000 lgal.                     | \$0.057 |

Maintenance Cost - not established as yet

### Conclusions

The wastewater treatment plant at Mattabi Mines performs very well and has given results that far surpass those expected.

References:

1. Water Pollution Control Directorate, Mine and Mill Wastewater Treatment, report No. EPS 3-WP-75-5, 1975.
2. Huck, P.M., K.L. Murphy and B.P. LeClair, Scavenging and Flocculation of Metal-bearing Wastewaters Using Polyelectrolytes, report No. EPS 4-WP-77-7, 1977.

## APPENDIX 'A' - Summary of Water Treatment Plant

Design Flow = 1,000 Igpm (273 m<sup>3</sup>/h)

### Line Feed System

- SCR controlled dry line feeder
- Signal from pH electrode in second mixing tank
- centrifugal slurring pump with constant flow of 30 Igpm (8.2 m<sup>3</sup>/h)

### Polyelectrolyte Feed System

- 1 batching tank, 1 feed tank
- 2 diaphragm - type metering pumps
- 0.17% feed concentration

### Line and Recycled Sludge Mixing Tank

- 5,280 Igals (24 m<sup>3</sup>)
- 3 HP propeller mixer
- retention time = 26 minutes

### Mixing Tank #1

- 10,560 Igals (48 m<sup>3</sup>)
- 2 HP turbine mixer
- retention time = 10 minutes

### Mixing Tank #2

- same as #1
- pH electrode

#### Flocculators

- 2 pipe flocculators
- velocity = 2.5 ft/sec. (0.76 m<sup>3</sup>/s)
- retention time = 35 sec.

#### Clarifiers

- 2 tanks, each 19 ft. (5.8 m) x 7 ft. (2.1 m) x 16 ft. (4.9 m) high
- 8 corrugated plate packs (TPS - 47 S)
- apparent overflow rate (based on surface area of, or floor area occupied by tanks) = 5,410 lgp/ft<sup>2</sup> (9.52 m<sup>3</sup>/h/m<sup>2</sup>)

#### Sludge Recycle Pump

- 15 HP, SCR drive
- Allis Chalmers 3x3x10 SRL-C Slurry pump
- 175 lgp (47.8 m<sup>3</sup>/h) capacity

#### Excess Sludge Pump

- 1.5 HP, progressing cavity MOYNO pump
- 10 lgp (2.7 m<sup>3</sup>/h) capacity
- SCR drive

#### Sludge Storage Tanks

- 2 tanks, each 10,560 lgal (48 m<sup>3</sup>)
- VIBRATROL sludge/water interface detectors



#### Sludge-to-Concentrator Pump

- WILDEN double-diaphragm air-operated pump

#### Retention Pond

- earthen bank lagoon
- overflow effluent weir
- 24 hour retention

#### Instrumentation (highlights)

- electromagnetic flow meter for influent
- fully automated sludge handling
- pH controlled lime slurry feed
- continuous monitoring and recording of reaction pH and TPS effluent turbidity

Coal Ash Management in Ontario Hydro  
by

J.H.P. Buckingham - Ash Management Supervisor

Central Services Division, Ontario Hydro.

Introduction

With the assurance of vast well established coal reserves, many power utilities throughout the world forecast a rapid growth in the construction of new coal fired power plants in the future. In the U.S.A. alone, over 200 such plants are currently under construction and scheduled to come on stream by the mid 1980's.

Throughout the world over one billion Mg<sup>+</sup> of coal will be consumed for the generation of electricity in 1979, and as a result well over 100 million Mg of coal ash will be produced.

In our Ontario Hydro system - where the production of coal ash in 1979 is likely to be over one million Mg - large volume utilization opportunities have suffered in the past, due mainly to the availability of natural materials, however today's ecological climate and energy conservation targets interface favourably with efforts to achieve the acceptance of coal ash as a resource for the future. This paper provides a profile of Ontario Hydro's coal ash management both historically and present day, together with their forecast future plans in pursuit of long term, large volume coal ash utilization.

+ Mg is the abbreviation for the S.I. Preferred unit "megagram", which is equal to 1 metric ton, sometimes referred to as "tonne".  
1 Mg or tonne = 1.102 tons (2000 lb).

## Coal Ash Production

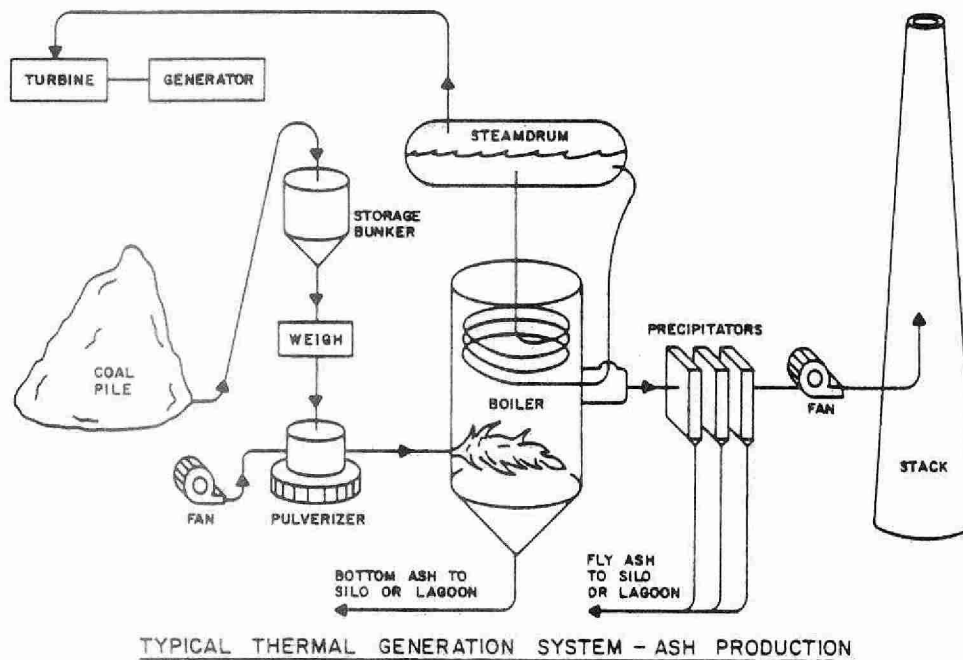


Fig. 1

The typical sequence of operations of our coal fired plants is shown diagrammatically in Fig 1. where, coal received during the shipping season is reclaimed and conveyed to storage bunkers in the power house. In order to raise steam, the coal is metered, ground by large pulverizers and blown into the boiler in the form of a fine powder where it instantly ignites and burns like a gas flame. The intense heat produces superheated steam to drive turbine generators. In the process, two types of ash are produced: fly ash - the light airborne particulate which is carried out of the boiler

in the flue gases - is removed by highly efficient electrostatic precipitators and collected in dry storage silos or sluiced to lagoons; and bottom ash - a combination of the heavier ash particulate and molten slag which forms on the internal surfaces of the boiler - collects in the bottom of the boiler where it is rough ground to aid in its removal and sluiced by high pressure water jets to either holding bins or lagoons.

Historically, Ontario Hydro's coal supplies have been of the U.S. bituminous variety from West Virginia and Pennsylvania. These are likely to be supplemented in the future with supplies of lower sulphur U.S. and low sulphur Western Canadian coals.

From performance, the U.S. bituminous coals consumed in our system have been found to contain an ash content of approximately 10%, of which 80% has appeared as fly ash and the remaining 20% as bottom ash. We anticipate no major change in these proportions with the lower sulphur coals, however due to the reduction in the calorific value of the Western Canadian coals an increase in the volume of ash production is anticipated.

Coal sources are a major influencing factor on the quantity and quality of ash produced. The quantity of ash is directly related to the coals' calorific value, and its quality is seen to vary mainly in the iron, lime and carbon contents.

A summation of present and forecast future coal ash production from all our stations is shown in Table 1.

| Generating Station | Coal Ash x 1000 Mg |      |      |      |      |
|--------------------|--------------------|------|------|------|------|
|                    | 1979               | 1980 | 1981 | 1982 | 1983 |
| R.L. Hearn         | 2                  | 2    | 1    | -    | -    |
| J.C. Keith         | 1                  | 1    | 1    | 1    | 1    |
| Lakeview           | 230                | 193  | 100  | 71   | 82   |
| Lambton            | 398                | 366  | 312  | 309  | 267  |
| Nanticoke          | 500                | 759  | 714  | 746  | 692  |
| Thunder Bay        | 14                 | 19   | 27   | 50   | 85   |
| Totals             | 1145               | 1340 | 1155 | 1177 | 1127 |

Table 1  
Ontario Hydro Coal Ash Production

### Detailed Characteristics of Ash

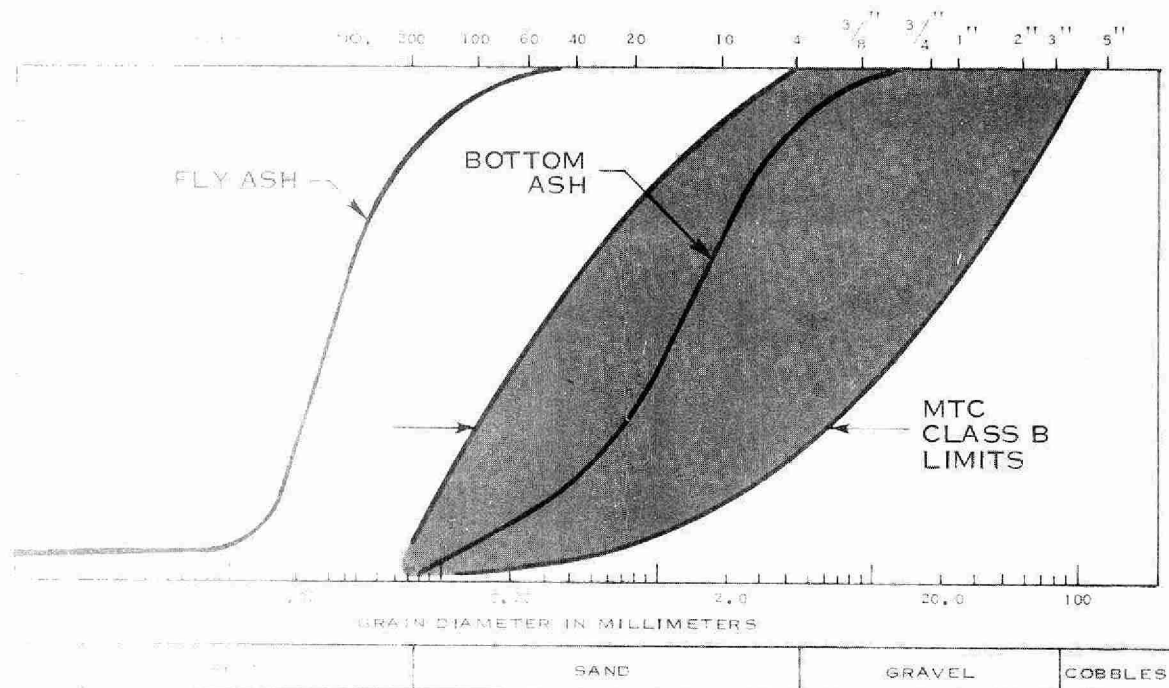
Ontario Hydro's coal ash is composed largely of compounds of silica, alumina, iron, lime, and carbon together with smaller quantities of magnesia, titanium, potassium, sulphur, and alkali compounds. Typical compositions for fly ash and bottom ash from our current operations are provided in Appendix I.

From a physical standpoint, fly ash is glassy rather than crystalline due to its thermal history. Fly ash particles are typically spherical and range in size from one to 150 microns with a mean diameter of 6 to 9 microns. Iron is present both as magnetic and non-magnetic oxides. Carbon particles in the fly ash tend to be somewhat coarser and more angular than the average particle size, and to display adsorption features common to that of coke.

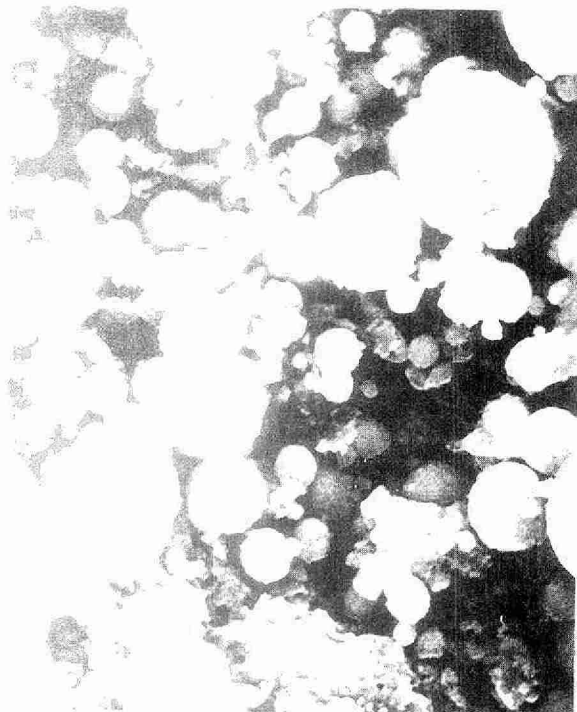
By contrast bottom ash is typically greyish black in colour, quite angular and irregularly shaped. The particles are somewhat porous and range from 3/4" gravel to a particle size passing 200 mesh presenting a composite material similar to that of Class B aggregate.

The following page identifies these physical characteristics more specifically.

# PHYSICAL PROPERTIES OF ONTARIO HYDRO FLY ASH AND BOTTOM ASH



GRAIN SIZE DISTRIBUTION CURVES FOR ONTARIO HYDRO FLY ASH, BOTTOM ASH AND MTC CLASS 'B' LIMITS



ELECTRON MICROGRAPH OF FLY ASH (4000 X)



BOTTOM ASH

BOTTOM ASH (TYPICAL)

### Coal Ash Storage

Currently, Ontario Hydro operates six coal fired generating stations: R.L. Hearn (Gas & Coal) located on the Toronto Waterfront, Lakeview in Mississauga, Lambton near Sarnia, J. Clark Keith in Windsor (currently under renovation), Thunder Bay and Nanticoke (one of the world's largest) located South of Hamilton on Lake Erie.

At the Lambton, Keith, Nanticoke and Thunder Bay Stations, provision was made for long term on site ash storage either in stockpiles or lagoons. The Hearn and Lakeview Stations have no large volume on site storage facility, and at the present time surplus fly ash has to be transported in \*pre-conditioned form to Ministry of the Environment approved landfill sites.

In view of its growing acceptability as a construction material, bottom ash is currently being stockpiled separately at our Lakeview, Lambton and Nanticoke Stations.

The location and estimated quantities of existing Ontario Hydro coal ash stockpiles are shown in Appendix 2 and 3.

\* The dry fly ash is thoroughly mixed with a 15% water addition to prevent in transit dust pollution, and to aid in its placement and compaction at site.

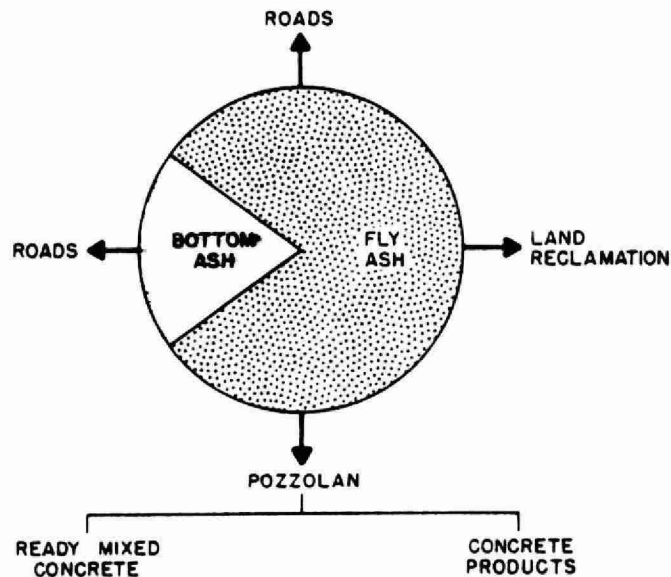


## Coal Ash Utilization

Ash utilization has long been an aim in many utilities involved in coal fired generation. The National Ash Association, formed fifteen years ago under the auspices of the U.S. Bureau of Mines and financed by its members has done much to promote the many uses for coal ash. The growing confidence in the availability of coal as a major fuel source in the future is triggering a growing international interest in ash utilization, and a great deal of research and development work is being carried out throughout the world in an endeavour to find new markets for this versatile material.

Due to the long term experience with large volume uses of ash and the dwindling availability of natural materials, the United Kingdom has achieved the greatest success in the past and annual utilization levels of over 50% or 6,000,000 Mg continue to be achieved.

Ontario Hydro's utilization experience is shown in Fig. 2. The use of ash has been developed from its singular use in land reclamation projects in the 1960's, to further uses as pozzolan, - partial cement replacement - and more recently as structural fill in road construction.



ONTARIO HYDRO'S COAL ASH UTILIZATION EXPERIENCE

Fig. 2

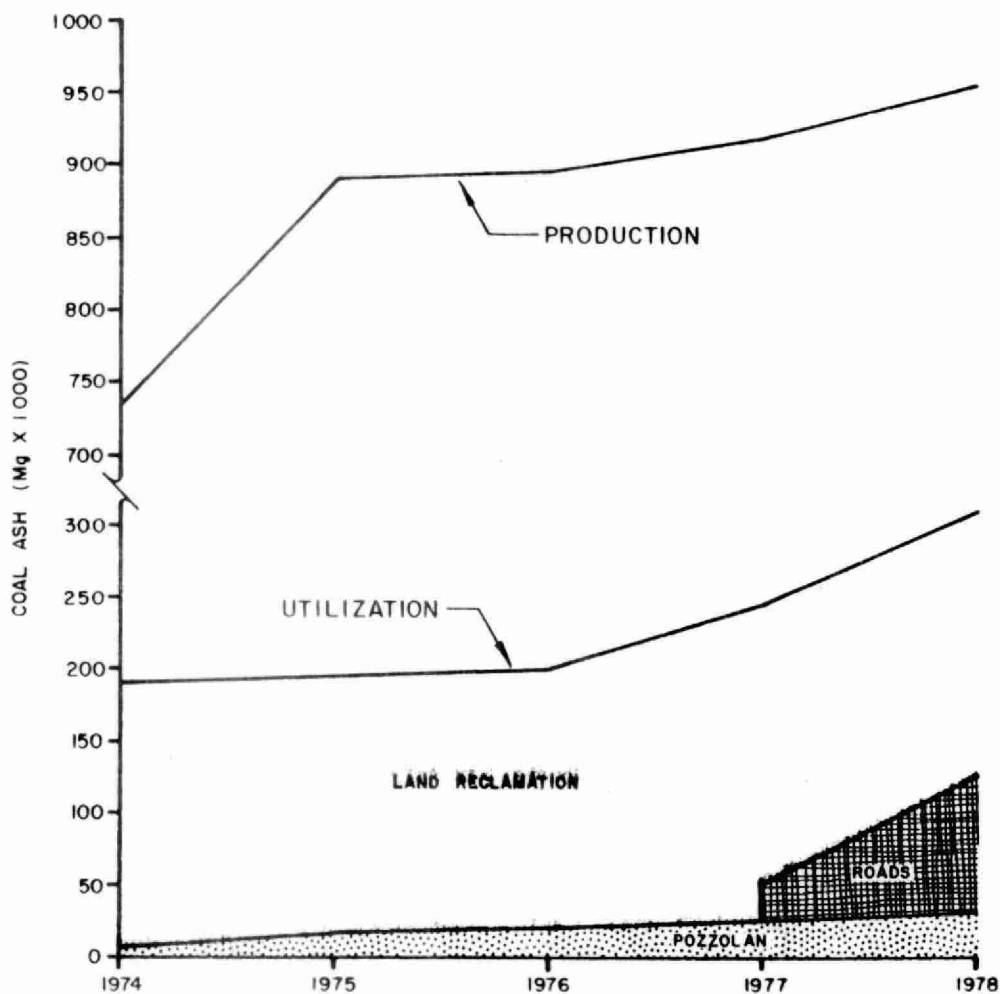
The development process has been slow for a variety of reasons which include; the time to attain customer confidence, the time to conduct research programs, and the time for staff to develop the necessary unique expertise for the marketing of coal ash.

The foregoing have been further aggravated over the years by the availability of natural materials, and the fears by many of using an untried "WASTE".

Customer confidence has been achieved by providing the necessary expertise to users for the design of fly ash concrete mixes, in assistance with materials handling problems, and by conducting research and test programs.

This type of support for the marketing effort is considered vital if a successful ash utilization program is to be ultimately achieved.

Ontario Hydro's actual ash utilization performance since 1974 is shown graphically in Fig. 3.



ONTARIO HYDRO'S COAL ASH UTILIZATION PERFORMANCE

Fig. 3.

In conjunction with Figs. 2 and 3, the following detail is provided :

#### Land Reclamation

Historically, the greatest use for Hydro ash has been as fill material in land reclamation projects. Surplus Lakeview and Hearn ash has been used in the rehabilitation of mined out quarries to develop recreational parkland. Examples of these can be seen at Oakridge Park, and Fly Ash Park both located in Mississauga. See Figs. 4 and 5.

In conjunction with the Borough of Etobicoke, the Booth Pit located on Horner Avenue - a mined out shale quarry (surrounded by residential and industrial development) with a capacity for 800,000 Mg of ash - is currently being restored for recreational purposes by the use of surplus Lakeview and Hearn coal ash. See Fig. 6.

In applications such as these, site management has been found to be a vital requirement in ensuring environmental acceptability. Being light and easily airborne pre-conditioned fly ash must be placed, spread and compacted as received and not left in loose mounds to air dry. Additionally, in extremely dry weather frequent dust control is necessary particularly on access and in pit roadways. This can be achieved by conventional water sprinkling equipment.

Oakridge Park  
Mississauga

Fig. 4.



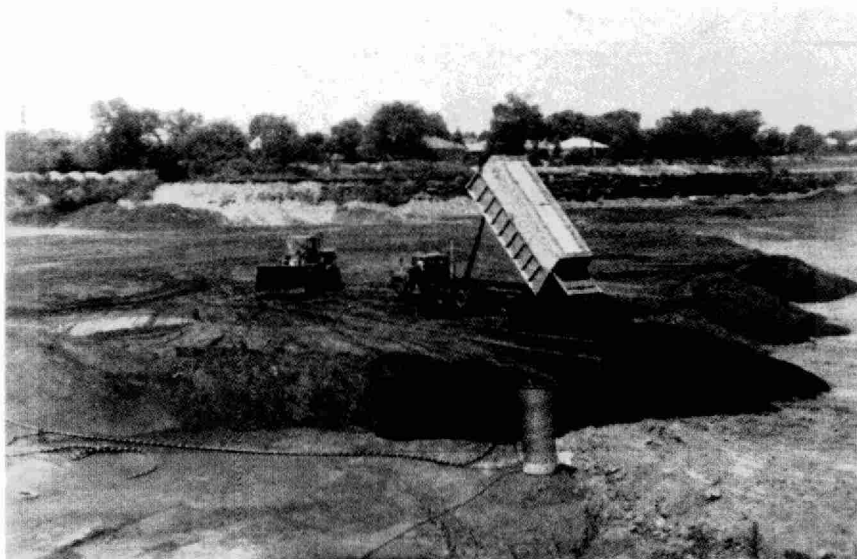
Fly Ash Park  
Mississauga

Fig. 5.



Booth Pit  
Borough of  
Etobicoke

Fig. 6.



It is recognized that fly ash contains 1% soluble material of which approximately half are sulphates and these constituents represent a justifiable concern.

Ontario Hydro's Chemical & Civil Research Departments have, - for the past two years - been conducting a study at the Fly Ash park location. The water quality in test wells within and around the site has been monitored and the ash and soil from the test borings examined in order to gather data to determine the soil ion exchange capacity, and the rate of leachate migration. A similar ongoing monitoring program is being conducted at the Booth pit location.

The preliminary findings of these and other laboratory shake type leaching tests indicate that the ash leachate is essentially a basic sodium and calcium sulphate solution with small or trace amounts of other elements present. The high pH appears to suppress leaching of elements such as heavy metals, while species with anionic behaviour such as borate for instance, are only present in small concentrations. The relatively low levels of dissolved solids in the ground water adjacent to the sites, compared to that found within the deeper sections of the site itself seems to indicate that the effect of the ash is quite localized, and that the rate of leachate production and migration is both small and slow. These studies are continuing.

## Fly Ash as a Pozzolan

Hydro fly ash is a pozzolan, or partial replacement for portland cement in the manufacture of ready mixed concrete and concrete products. The word 'pozzolan' derives from the days of the Romans who used natural volcanic ash found near the town of Pozzuoli near Naples in Italy. This volcanic ash when mixed with lime and water became cementitious and was used in the mortars of those days. Hydro fly ash has similar characteristics, and when used as an ingredient in concrete or concrete products joins with the available hydrated lime to develop even more cementitious compounds, resulting in the following benefits :

### (1) In fresh concrete

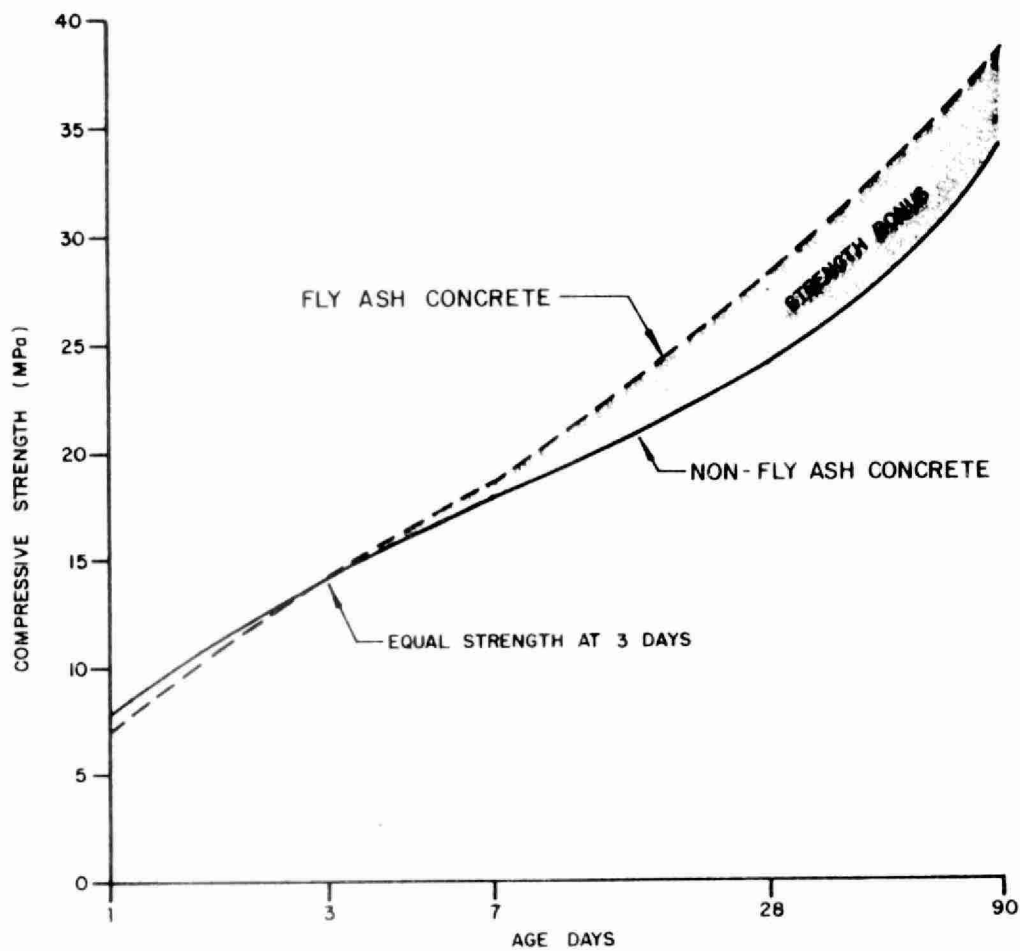
- A reduction in portland cement and therefore a major economic benefit to the user.
- Increased workability: Added fines in the form of spherical fly ash particles lubricate the mix to provide greatly increased workability with equal or lower water demand.
- Reduced segregation and bleeding.
- Improved pumpability.
- Better consolidation around closely spaced reinforcing.

(2) In hardened concrete

- Less heat of hydration: Since the hydration of fly ash produces about half the amount of heat of an equal weight of cement, temperatures in massive sections are lower thus thermal cracking is reduced.
- Higher sulphate resistance: Fly ash greatly improves the resistance of concrete to sulphate attack, regardless of the type of portland cement used.
- Freeze-thaw durability: Concrete containing fly ash displays durability characteristics similar to concrete without fly ash, provided that both mixtures are equally air-entrained and have equal compressive strength.
- Improved watertightness: The combination of lower permeability and reduced amounts of leachable calcium hydroxide in fly ash concrete make it especially valuable in water containment structures.
- Reduced alkali-aggregate reaction: Fly ash inhibits the destructive reaction between cement alkalis and certain reactive siliceous aggregates.
- Long term strength development: Fly ash provides a strength bonus at later ages. See Fig. 7.



- Reduced creep: A University of Toronto study has established that the creep of fly ash concrete is less than the creep of non-fly ash concrete.



STANDARD CURED STRENGTH DEVELOPMENT

Fig. 7.

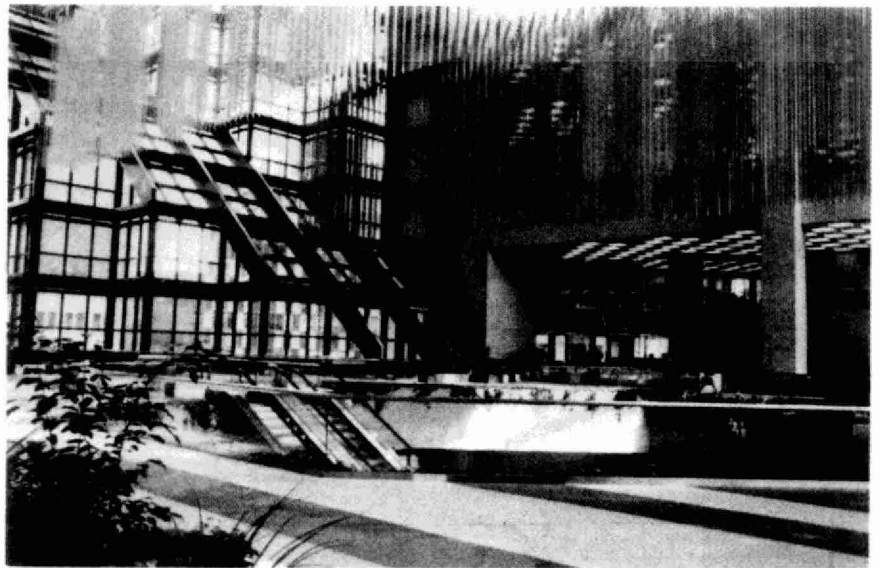
- Fly Ash can assist in the reduction of energy: Portland Cement is an energy intensive product, over 4,000,000 BTUs of energy being required to produce 1 Mg. The use of fly ash in the production of concrete and concrete products reduces the cement requirements of the mix, and therefore fly ash can contribute to the energy reduction effort.

To date the most prestigious project involving Ontario Hydro fly ash in concrete was in the construction of the high strength support columns for the Royal Bank Plaza in downtown Toronto. See Figs. 8 and 9. In this project, concrete compressive strengths of 55 MPa were specified and actual strengths of 75 MPa achieved.

Ontario Hydro continues to market fly ash from their Lakeview Generating Station in Southern Ontario for use as a partial cement replacement in the manufacture of ready mixed concrete, concrete block, concrete brick and grouting applications. In 1974, sales of 7,000 Mg were achieved. In 1978, better than 30,000 Mg were sold. Greater market penetration for this material is forecast for the future.

Royal Bank Plaza  
Lower Level  
Showing high  
strength columns.

Fig. 8.



Royal Bank Plaza  
external view.

Fig. 9.



## Ash in Road Construction

Ash in road construction in Ontario is becoming the fastest growing large volume use for coal ash at the present time.

From an ecological standpoint the use of the material in this application can play a vital part in the preservation of our natural resources.

From a civil engineering aspect, the material is ideal as a structural fill exhibiting similar properties to those of fine grained soil and one which can be placed by conventional construction methods.

Because of their fine particle size some fly ashes are considered to be frost susceptible, and in order to ascertain the effects of frost heave on Ontario Hydro fly ash our Civil Research Department has recently completed a study on a test embankment designed to simulate a typical highway fly ash structural fill. It was found that the effects of frost heave were minimal, indicating that no special treatment is necessary other than the need for a nominal soil cover.

In conjunction with the experiences of the use of ash in road construction in Europe, and technical literature made available from the National Ash Association, the first use of Ontario Hydro coal ash in road construction in Ontario was achieved in 1978.

This initial project - see Figs. 10, 11 and 12, used 113,000 Mg of ash from the J. Clark Keith lagoon in Windsor. The material was hauled 12 km and used as a structural fill in an overpass as part of the E.C. Row Expressway construction program. The material's lightweight and close proximity to job site were major reasons for its selection.

This project involved the decanting of a water table that existed below the surface of the ash in the lagoon. This was achieved by cutting trenches with backhoe equipment. The decanted material was excavated and stock piled to allow further drying, and then loaded into conventional tractor-trailer units. At the job site it was spread in 30 cm layers and compacted to specifications. Compaction levels ranging from 95% to 100% of standard laboratory proctor were achieved.

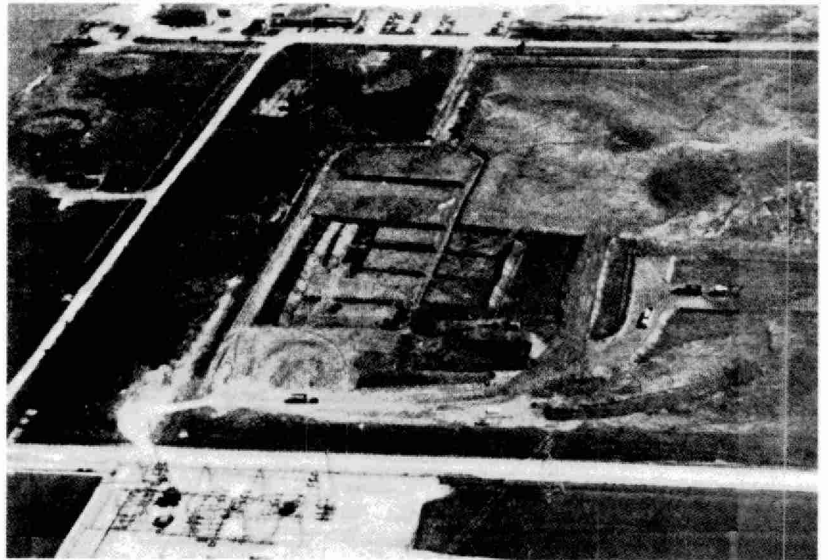
The success of this project has led to another Ministry of Transportation & Communications contract in 1979. An estimated 220,000 Mg of ash from the Lambton Generating Station storage area will be used in an approach ramp to the #402 Highway in Sarnia.

A research and testing program by Ontario Hydro's Civil Research staff is continuing in order to assist in the promotion of coal ash in road construction in the years ahead.

J. Clark Keith lagoon:

Aerial view of coal ash  
reclamation program

Fig. 10.



E.C. Row - Walker Road  
overpass:

Spreading & Compacting  
coal ash at site

Fig. 11.



E.C. Row - Walker Road  
overpass:

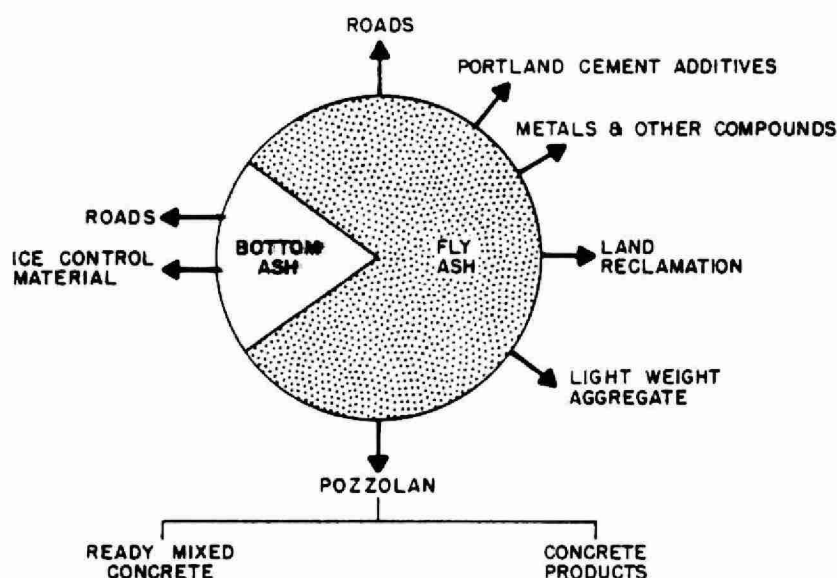
Aerial view of coal ash  
construction site

Fig. 12.



Fact sheets identifying the physical properties, and advantages for the use of fly ash in structural fill applications, and bottom ash as a granular material are provided in Appendix 4 and 5.

## Future Potentials for Ontario Hydro Coal Ash



### ONTARIO HYDRO'S FUTURE COAL ASH UTILIZATION POTENTIALS

Fig. 13.

Fig. 13 above identifies the considered large future utilization possibilities for Ontario Hydro coal ash, and currently negotiations are progressing in order to further some of these opportunities.

The use of ash in Land reclamation, as a Pozzolan, and in Road construction have already been identified, and these uses are predicted to continue. In addition to these now historical uses, we predict that in the future the following additional markets will be developed :



- (1) Fly ash as an additive in the production of cement, where its high silica and alumina characteristics will aid in the upgrading required for the ground limestone, and assist in the reduction of grinding costs.
- (2) Fly ash as the raw material in the production of light-weight aggregate. To manufacture this aggregate, water is first added to the fly ash. The dampened material is then placed on a revolving, saucer-shaped pelletizer. In much the same way as with a growing snowball, the fine particles combine to make small pellets. As they reach the desired size they discharge themselves from the revolving saucer. They are then transported by a conveyor belt to the sintering furnace. In the extreme heat, the carbon in the soft pellets ignites fusing the minute particles together producing synthetic, light-weight stones. Consistent carbon content is a critical feature of the sintering operation --- too little carbon and no fusing is achieved, too much and the pellets join together to produce a massive clinker.

This aggregate can be used in the production of light-weight concrete blocks and light-weight structural concrete. The major benefit resulting from its use is a reduction in the dead weight of the structure --- a

vitaly important factor when building in critical load-bearing locations.

The Harbour Castle Hotel in Toronto, constructed on landfill at the edge of Lake Ontario (a fact that imposed load-bearing restrictions) was built using light-weight aggregate made from Ontario Hydro ash. As a result, the architect was able to design an increase in the height of this structure.

- (3) Fly ash in the production of metals and compounds - although identified, is likely to be the least realistic potential for us in the immediate future. Internationally, a great deal of research and development work is being performed to try to isolate the Aluminum Oxide (normally about 20% of the ash) economically, and eventual success will be achieved. In our opinion, unless extraction of the remaining materials i.e. silica, iron, etc. is also achieved, 80% of the ash will become a possible disposal problem.
- (4) Bottom ash as ice control material - is a large market in many areas of the U.S. In West Virginia alone, over 100,000 Mg was used in 1978 on rural roads in preference to sand and salt mixes. In conjunction with the Ministry of Transportation & Communications a test program is scheduled for this application using Lambton bottom ash

on rural roads in Western Ontario next winter.

Even further potentials for Ontario Hydro coal ash exist, and these will be actively pursued in the future. They include :

- the use of fly ash in clay brick production - to produce lighter weight units
- as filler material in asphalt production
- in the production of insulation material
- in the production of refractory bricks
- in the fixation of liquid chemical wastes
- as blasting grit and roofing granules

and no doubt with the continual drain on our natural resources and the escalating costs of construction materials, even further market potentials will appear.

### Summary

The expanding dependence on coal for the generation of electrical energy is assured throughout the world for the long term future, and internationally coal ash utilization programs will continue to be developed to meet the differing preferences best suiting the requirements of the Provinces, States or Countries concerned.

In Ontario Hydro, the Ash Management Group will continue to develop their utilization program on the basis of the most economical and ecological benefits for our Province and its people.

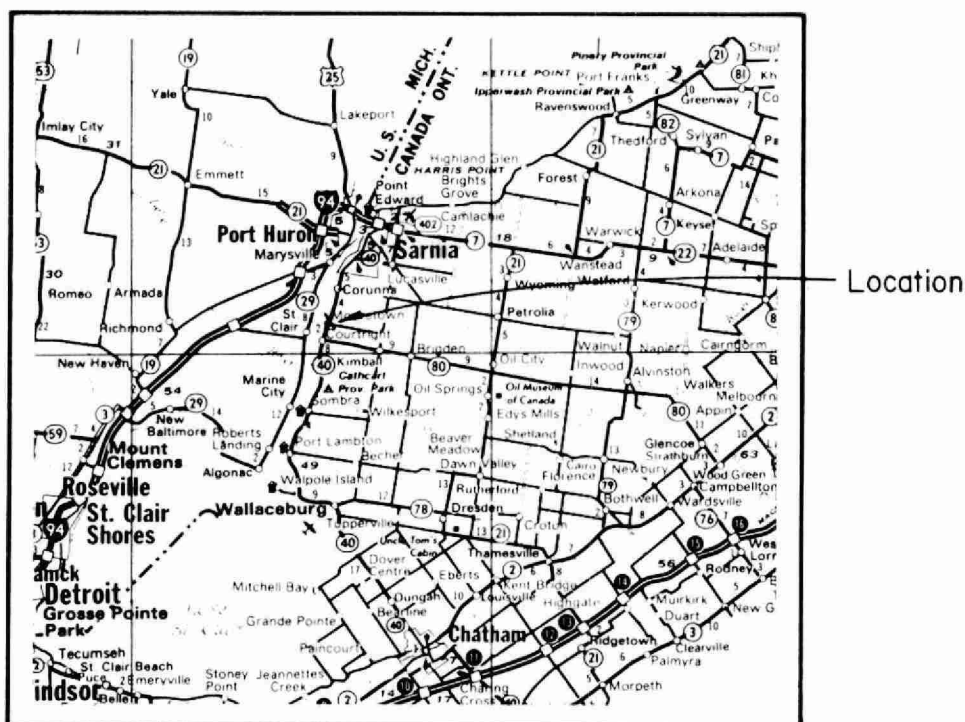
The many future opportunities for coal ash in Ontario have been identified, but utilization development will be seriously affected while this material remains under the stigma of the WASTE classification.

We trust that our current dialogue with the Ministry of the Environment will result in a reclassification for coal ash, and they, like we and our International Utilization cousins recognize the exciting potential for what is currently considered simply a waste material, but which in fact is truly a RESOURCE for the FUTURE.

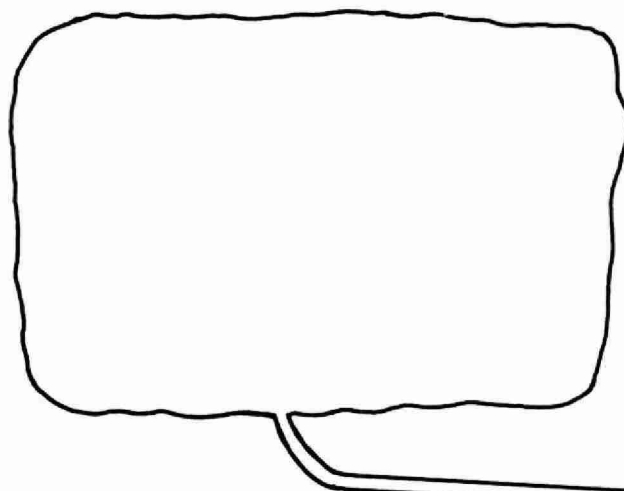
TYPICAL ANALYSES OF ASH FROM CURRENT OPERATIONSPER CENT BY WEIGHT - MOISTURE-FREE BASIS

|                                     | <u>FLY ASH</u> | <u>BOTTOM ASH</u> |
|-------------------------------------|----------------|-------------------|
| SILICON (AS $\text{SiO}_2$ )        | 43.6           | 45.4              |
| ALUMINA ( $\text{Al}_2\text{O}_3$ ) | 21.0           | 25.6              |
| IRON ( $\text{Fe}_2\text{O}_3$ )    | 17.0           | 13.4              |
| CALCIUM ( $\text{CaO}$ )            | 3.4            | 4.6               |
| MAGNESIUM ( $\text{MgO}$ )          | 0.9            | 1.1               |
| POTASSIUM ( $\text{K}_2\text{O}$ )  | 2.4            | 1.7               |
| SODIUM ( $\text{Na}_2\text{O}$ )    | 1.4            | 1.3               |
| TITANIUM ( $\text{TiO}_2$ )         | 0.6            | *                 |
| LEAD (Pb)                           | *              | 0.01              |
| ZINC (Zn)                           | *              | 0.02              |
| SULPHUR ( $\text{SO}_3$ )           | 1.4            | 0.42              |
| LOSS ON IGNITION (BASICALLY CARBON) | 8.0            | 2.0               |
| TOTAL WATER SOLUBLE MATERIAL        | 1.0            | *                 |
| SOLUBLE SULPHATES                   | 0.5            | *                 |

# LAMBTON G.S. (near Sarnia)



## Station Above Surface Disposal Area



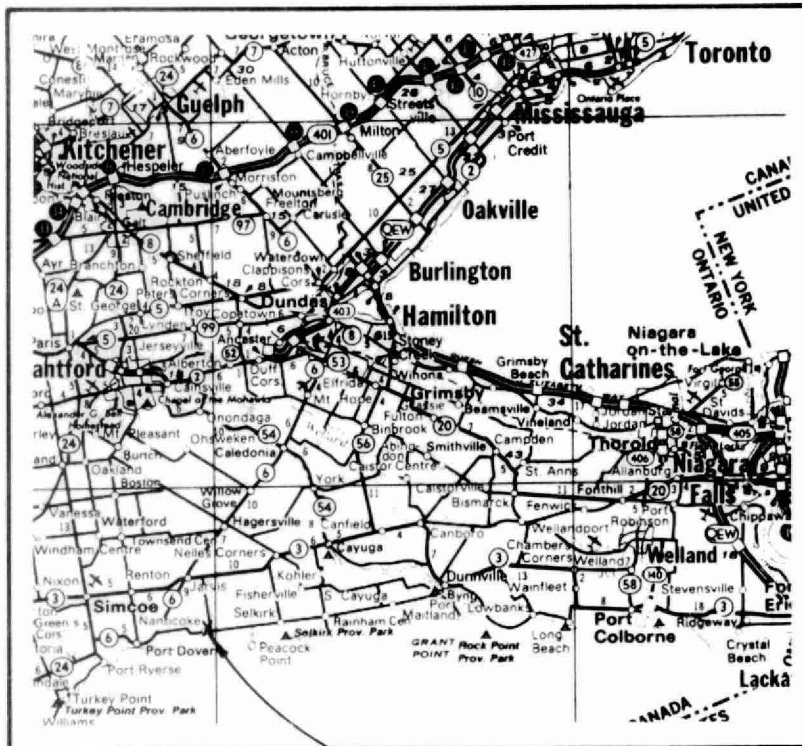
Estimated Ash Available  
3 000 000 Mg  
(as of March, 1979)



River Road

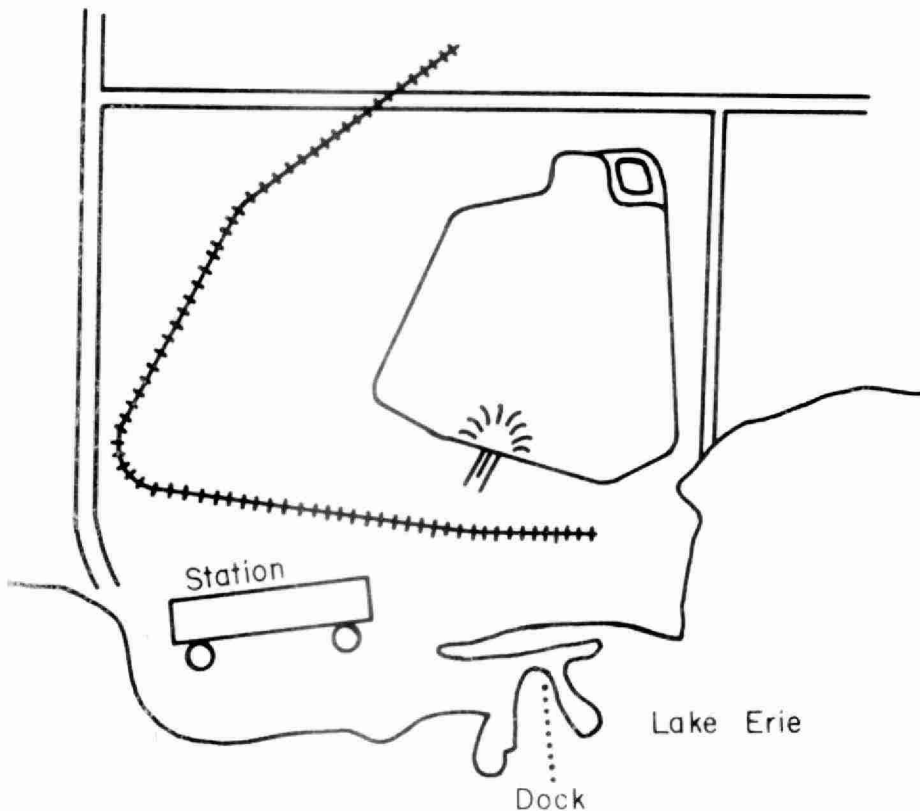
St. Clair River

# NANTICOKE G.S.



Location

## Lagoon - 75 hectares



Estimated Useful  
Ash Available  
1 500 000 Mg  
(as of March, 1979)

## FLY ASH IN STRUCTURAL FILL APPLICATIONS

### FLY ASH

- FINE GRAINED SPHERICAL GLASSY MATERIAL
- COLLECTED BY ELECTROSTATIC PRECIPITATORS FROM FLUE GASES
- GREY, SILT SIZED MATERIAL
- BULK DENSITY - LOOSE 800 TO 880 kg/m<sup>3</sup> (50 TO 55 pcf)

### APPLICATIONS

- BRIDGE APPROACHES
- ROAD CONSTRUCTION - CLOVERLEAFS
- LAND RECLAMATION SCHEMES FOR INDUSTRIAL AND RESIDENTIAL DEVELOPMENT
- PARK LAND DEVELOPMENT

### ADVANTAGES

- LIGHT WEIGHT - 1200 TO 1440 kg/m<sup>3</sup> (75 TO 90 pcf) COMPACTED
- ECONOMY
- REDUCES BORROW

### PHYSICAL PROPERTIES

- HIGH PERMEABILITY WHEN COMPACTED ( $10^{-5}$  cm/s)
- ADEQUATE STRENGTH  $c_u = 34$  TO  $69$  kPa (5 TO 10 psi)  
 $\phi = 30^\circ$  TO  $35^\circ$
- STRENGTH CAN BE INCREASED BY STABILIZATION
- SILT SIZED - SOME FLY ASHES ARE FROST SUSCEPTIBLE
- MODERATE CAPILLARY ACTION - MAY REQUIRE A CUT OFF
- LOW COMPRESSIBILITY
- LEACHING - CONTAINS SOME CALCIUM AND SULPHATES
  - REQUIRES CONTROL AGAINST INFILTRATION
  - COMPACTED EMBANKMENTS SHOULD REPRESENT NO DANGER TO SURROUNDING GROUNDWATERS

### CONSTRUCTION PROCEDURES

- HANDLED LIKE CONVENTIONAL SOIL
- MAY REQUIRE WATERING AND THIN COVER DURING DRY PERIODS
- SOIL COVER REQUIRED FOR VEGETATION
- CONCRETE REQUIRES MOISTURE PROOF MEMBRANE
- NO RECORDS OF CORROSIVE ATTACK TO GALVANIZED CULVERTS



BOTTOM ASH AS A GRANULAR MATERIAL

BOTTOM ASH

- CLINKER TYPE ASH FROM BOTTOM OF FURNACE
- GREY TO BLACK, ANGULAR, SLAG-LIKE
- BULK DENSITY - LOOSE 1120 TO 1280 kg/m<sup>3</sup> (70 TO 80 pcf)

PHYSICAL PROPERTIES

- LIGHT WEIGHT - 1280 TO 1440 kg/m<sup>3</sup> (80 TO 90 pcf)
- WELL GRADED, LOW IN FINES, MEETS MTC SPECIFICATIONS FOR GRANULAR B & C
- COHESIONLESS, HIGH FRICTIONAL ANGLE ( $\phi = 40^{\circ}$ )
- PARTICLES ARE SOUND AND DURABLE (MEETS MTC SPECS)
- HIGH PERMEABILITY ( $10^{-3}$  cm/s)

UTILIZATION

- CLASS B GRANULAR SUB - BASES
- CLASS C BACKFILL
- ABUTMENT BACKFILL
- SURFACE TREATMENT AGGREGATE
- COLD MIX AGGREGATE
- ICE CONTROL MATERIAL
- STABILIZED BASE MATERIAL
- FILTER MATERIAL

CONSTRUCTION PROCEDURES

- HANDLED LIKE CONVENTIONAL GRANULAR MATERIAL
- CONCRETE REQUIRES MOISTURE PROOF MEMBRANE
- NO RECORDS OF CORROSIVE ATTACK TO GALVANIZED CULVERTS

Performance Report on a New Heavy Metals Removal  
System Via Sulfide Precipitation  
by  
S.R. Korchin, Market Specialist, The Permutit Co.,  
Paramus, New Jersey

INTRODUCTION

In the past few years, regulatory agencies have been concerned over the discharge of so-called heavy metals, because heavy metals which include zinc, copper, cadmium, nickel, chromium, mercury, lead, etc. have been found to have a delayed but serious impact on the natural food chain, going from algae through lower aquatic life to higher animals and humans. The natural concentration of such metals in surface water is exceedingly small, but concentrations increase along the food chain until toxic levels can destroy certain species. For instance, populations of shellfish have been eliminated in some areas and there have been cases of brain damage, birth defects and death to human beings attributed to biomagnification of some heavy metals. Mercury discharges in Minimata, Japan, were responsible for some rather gruesome damage.

When heavy metals are discharged into municipal sewage treatment plants, there is some danger of direct toxicity to essential bacteria. Normally, the heavy metals are concentrated in the sludge produced. This sludge can be toxic to plants if applied to land or to marine life if dumped at sea.

In many cases, mixtures of these heavy metals have been treated by pH adjustment, with either lime or caustic soda, to cause precipitation of a metal hydroxide sludge. This is commonly

## INTRODUCTION (Continued)

known as the "lime and settle" or hydroxide process.

Chromium presents a special problem when it is present as a chromate in the hexavalent form. Before hexavalent chromium can be precipitated, it must be reduced to the trivalent state. The reduction step is commonly carried out at a pH of about 2, with the aid of a reducing agent, such as sodium metabisulfite. When reduction is complete, pH must be adjusted again to allow the formation of trivalent chromium hydroxide. As a result, wastes containing hexavalent chromium are usually segregated from other wastes and treated separately.

There are inherent problems with the hydroxide process, since it is often not capable of removing sufficient amounts of the heavy metal contaminants to achieve specified discharge levels. Figure I illustrates the amphoteric properties of the metal hydroxides. An operating pH ideally suited for good removal of one metal causes another metal to go into solution. The solubility curves suggest that the pH best suited for removal of zinc is about 10.0. However, at this pH, chromium has a solubility of about 5 mg./l, well above the maximum limits specified for this metal. Although solubilities will vary with composition of the waste, the amphoteric nature of the metal hydroxides make it impossible to obtain good removal of all metals.

# SOLUBILITIES OF HEAVY METAL HYDROXIDES

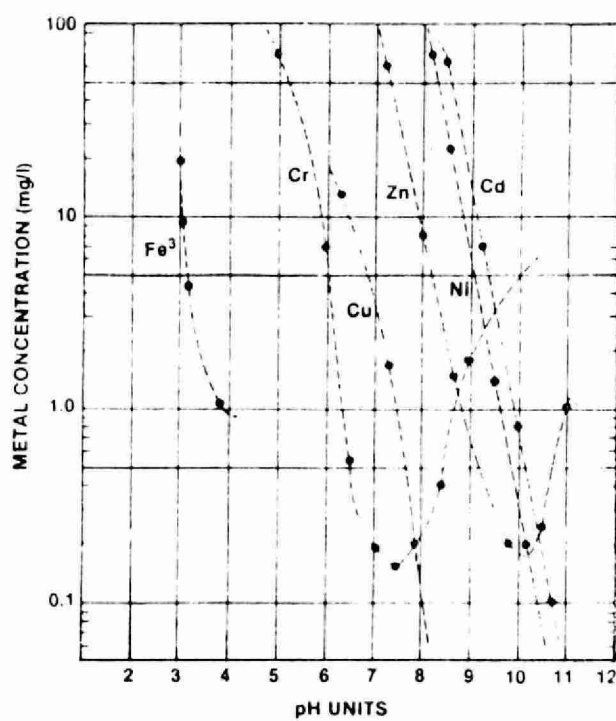


Fig. I

## INTRODUCTION (Continued)

Additionally, the presence of chelating agents or other complexing compounds in the waste may cause the metals to remain in solution in spite of pH adjustment. Particularly in plating operations, materials such as EDTA, Rochelle Salts, etc. are added to plating solutions to keep the heavy metals in solution. Proprietary compounds are available as additives for this purpose.

Figure II illustrates a comparison of the solubilities of metal hydroxides and metal sulfides. Metal sulfides do not exhibit the amphoterism of metal hydroxides. In addition, their solubilities are orders of magnitude below those of metal hydroxides and monotonically decrease with increasing pH.

The idea of using sulfide ion for precipitating heavy metals out of solution is not a new one. Clearly, the lower solubility of metal sulfides is advantageous. However, the most common source of sulfide ion, hydrogen sulfide gas, is extremely toxic and would require safety precautions unusually stringent for common industrial practice.

As a practical matter, most waste streams are subject to variations in flowrates and metal concentrations, and it is difficult to add the stoichiometrically correct quantity of sulfide ion to cause precipitation. Insufficient sulfide ion will not give

# SOLUBILITIES OF METAL HYDROXIDES AND SULFIDES

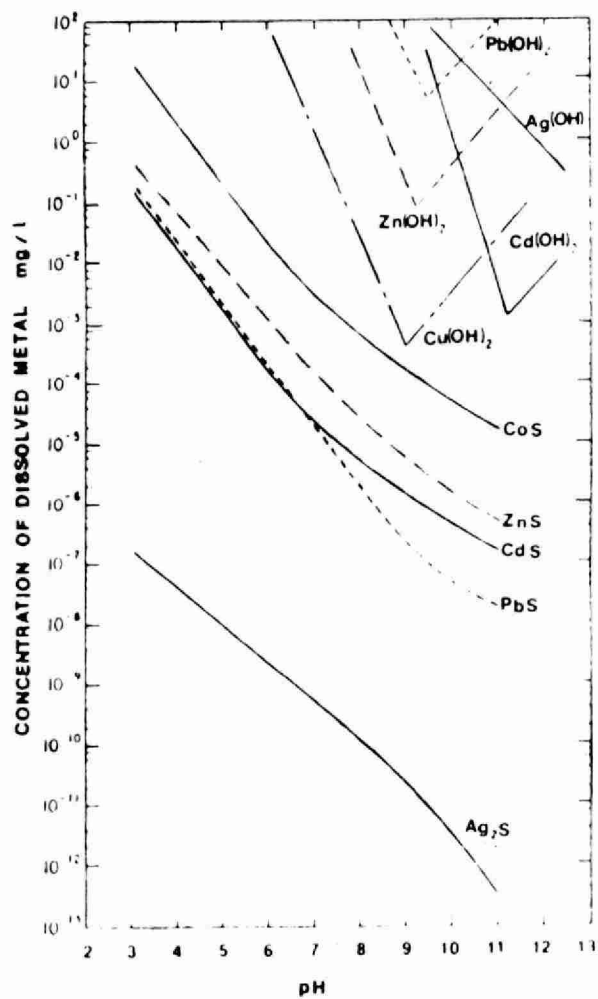


Fig. II

## INTRODUCTION (Continued)

complete precipitation, while excess sulfide will show up in the effluent water. The latter condition can lead to a problem with the evolution of hydrogen sulfide, which has an objectionable odor.

However, an innovation which allows a source of soluble sulfide ion is the introduction of the Sulfex process for heavy metals removal. Sulfex uses an insoluble salt as the source of sulfide ion. In order for the process to work, the solubility of the insoluble salt chosen must be greater than the solubility of the heavy metal sulfides to be precipitated. Ferrous sulfide ( $\text{FeS}$ ) fits these requirements. Since ferrous sulfide has a greater solubility than heavy metal sulfides from metal finishing waste streams, the Sulfex process uses ferrous sulfide as a source of sulfide ions. In addition, proper operation obviates any danger of hydrogen sulfide generation.

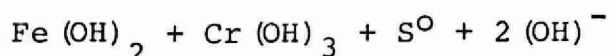
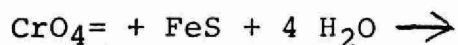
Of course, one readily available source of ferrous sulfide is from pyrites; although it would be logical to assume that pulverized pyrite could be used to precipitate these heavy metals, in actual practice, it is found that the particle size provides little useful surface area for sulfide precipitation. Since only the surface of the large particles would be useful, much iron sulfide would be wasted.  $\text{FeS}$  works best as a freshly prepared slurry. The freshly prepared material has a large reactive surface.

## INTRODUCTION (Continued)

The Sulfex reaction is quite simple as indicated below:



Use of a sludge blanket clarifier allows excess iron sulfide to handle surges of high metal concentrations, since the clarifier contains a large quantity of active iron sulfide. Additionally, hexavalent chrome can be reduced in a single step and removed as the trivalent hydroxide, as indicated below:



## DESCRIPTION OF PROCESS

The United States Environmental Protection Agency awarded a grant to the Holley Carburetor Company, a Division of Colt Industries in Paris, Tennessee, U.S.A. to demonstrate the effectiveness of sulfide precipitation in removing heavy metals from their wastewater discharge to the city sewer. The Sulfex process developed by the Permutit Company was tested in preliminary pilot plant work at the Permutit Research and Development Center, under a grant to the National Association of Metal Finishers by the United States EPA. At the Holley Carburetor plant, the Udyllite



DESCRIPTION OF PROCESS (Continued)

processes are used for chromate coatings of aluminum and zinc carburetor castings before assembly and are chemically treated according to finishing specifications established by the automotive industry. In addition to chromium and zinc, a full scale waste treatment system is used to remove suspended material, such as aluminum, iron, and phosphate precipitates from the plant's combined metal finishing process waste water.

The processes commonly used at Holley Carburetor are:

- (1) Alkaline deoxidizing of zinc and mild phosphoric acid etch prior to chromate coating.
- (2) Alkaline deoxidizing of zinc only.
- (3) Direct chromate coating of zinc.
- (4) Chromate conversion coating of zinc.

The first two processes are for thermally deburred zinc carburetor castings. The third process is for zinc parts, not thermally deburred prior to chromate conversion coating.

The three major factors affecting the concentration of metals in the waste discharge are the process selection for metal finishing, production schedule and various operational aspects of the Udyllite system.

The City of Paris, Tennessee passed an ordinance on 6 July 1978, establishing limiting concentrations in waste as received at the City Sewer Treatment System, based on the production criteria passed through sludge contamination and unit operation inhibition. Table I gives the limiting concentrations in the waste received at the City of Paris Sewer Treatment System.

The waste treatment system used at Holley Carburetor is shown in Figure III. This schematic diagram shows the waste treatment system, which is designed to handle the entire rinse flow from

TABLE 1

LIMITING CONCENTRATIONS IN THE WASTE RECEIVED  
AT CITY OF PARIS SEWER TREATMENT SYSTEM

| <u>Parameter</u>      | <u>Maximum Conc. mg/l</u> |
|-----------------------|---------------------------|
| Boron                 | 0.2                       |
| Cadmium               | BDL*                      |
| Chromium (hexavalent) | 0.4                       |
| Chromium (Total)      | 1.0                       |
| Copper                | 1.0                       |
| Cyanide               | 0.2                       |
| Lead                  | BDL*                      |
| Nickel                | 0.1                       |
| Zinc                  | 0.1                       |

\*Below Detectable Levels

# FLOW DIAGRAM

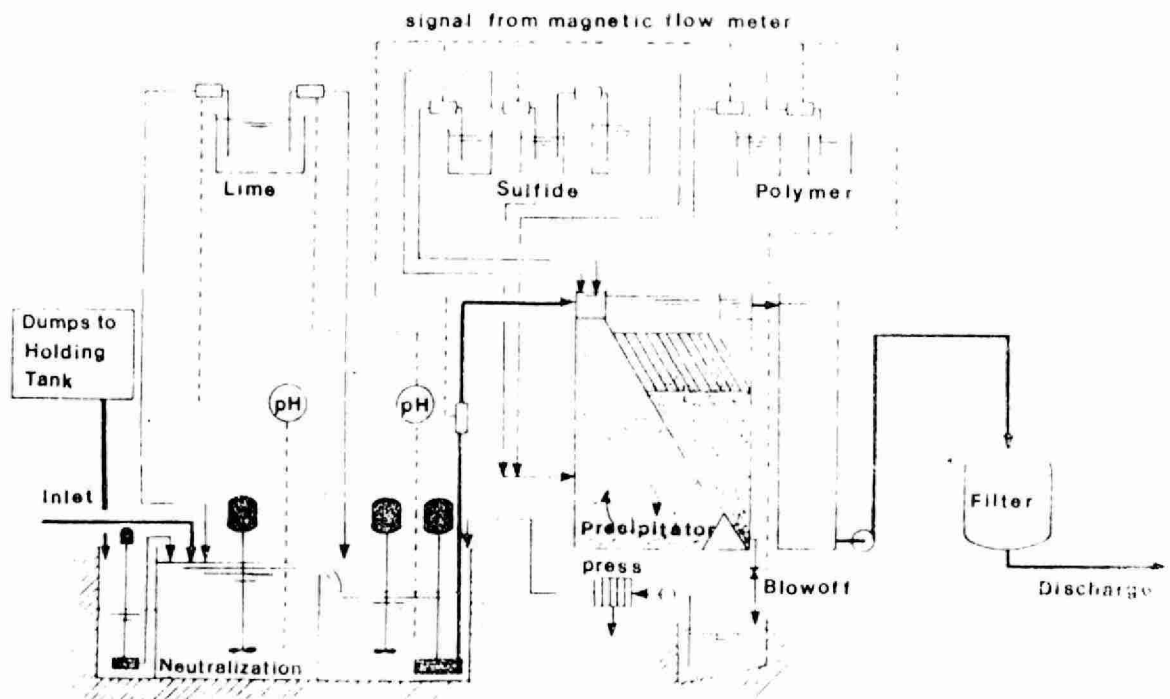


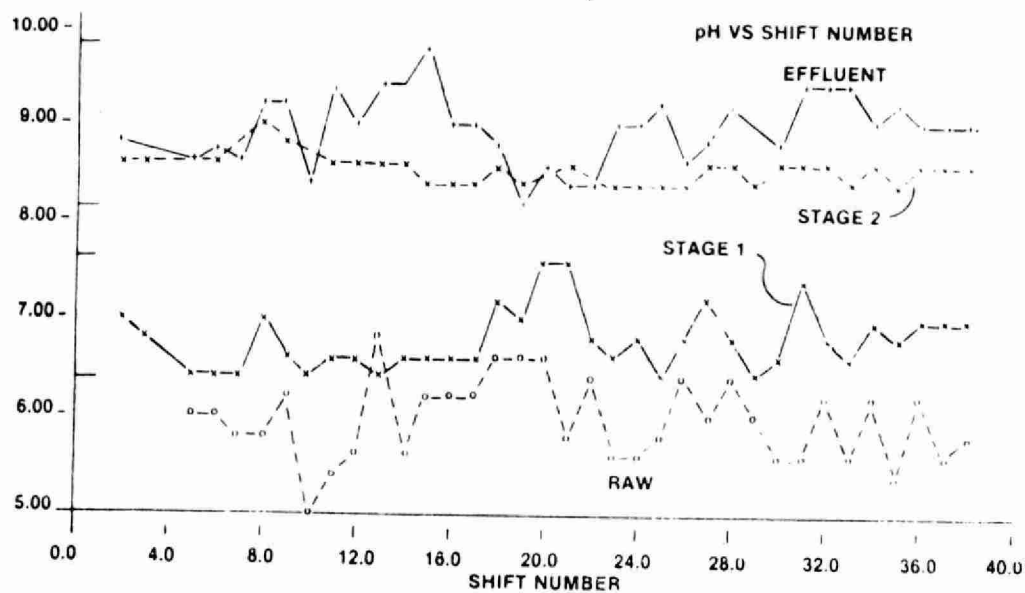
Fig. 3

the plating line of  $8.0 \text{ M}^3/\text{hr}$  (35 U.S. gpm). The unit operates 16 hrs./day. Treatment consists of neutralization, precipitation, clarification, filtration and sludge dewatering. All rinse water enters a two-compartment basin. The first compartment has retention time of 105 minutes and the second compartment, which normally operates with an average depth of 1 meter, has detention time of about 80 minutes. This second compartment is operated at a low level to accommodate filter backwash. The primary function of these two holding compartments is to permit neutralization of the waste to a pH of about 8.5, although equalization of the flow is a secondary benefit. The two-step neutralization is controlled by pH sensing devices. Neutralization is with lime. The metering pump in the first step operates in an on-off mode, while in the second step the metering pump has electronic stroke adjustment controlled by the degree of deviation from the pH setpoint. Figure IV, shows the raw waste effluent characteristics, as well as comparative pH data, for neutralization and plant effluent.

Neutralized waste is then pumped to the clarifier where FeS slurry and a polymer are added. Rate of addition is kept proportional to influent flow.

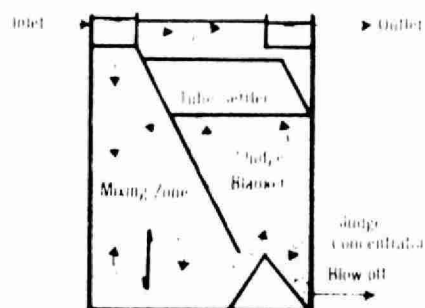
The clarifier used is a sludge blanket type, as illustrated in Figure V. A slowly rotating mixer underneath the curtain baffle promotes the formation of the floc. The floc mixture

Fig. IV



Average pH Value of Raw Influent, Neutralization Stage I and II, and Precipitator Effluent as a Function of Time

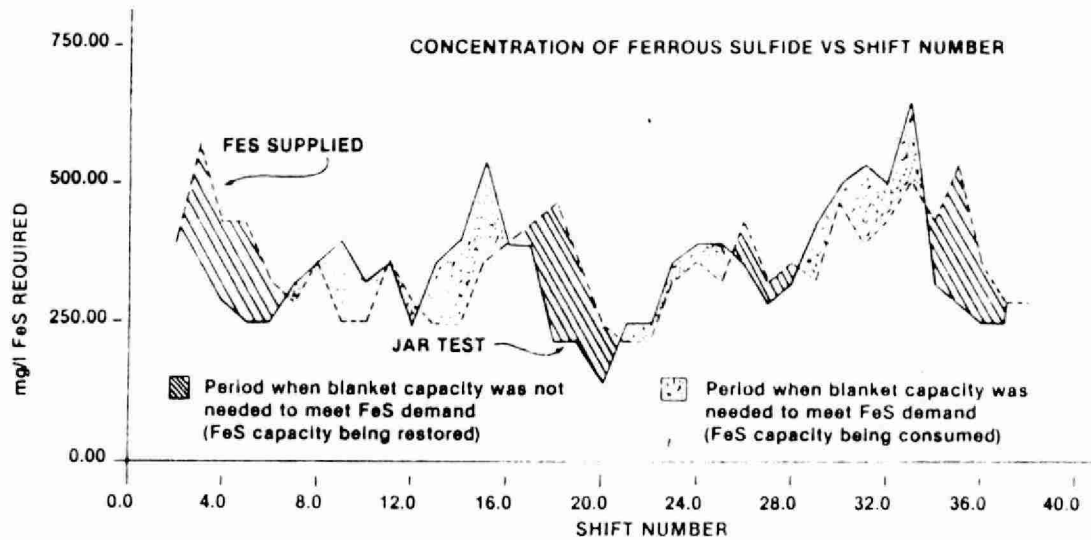
Fig. V



HULL PRECIPITATOR

passes underneath the baffle into a section where the rise rate diminishes, as the top of the unit is approached. This produces a sludge blanket with a sharp line of demarcation between the top of the blanket and the clear water above it. This blanket of suspended solids ranging in concentration from 5000 mg/l to 15,000 mg/l may consist of up to 50% active FeS. It is this reservoir of FeS, which allows the system to accommodate wide variations of influent metal concentrations with no change in effluent quality. Jar tests were run on samples taken from the second neutralization basin to determine the amount of iron sulfide required for precipitation. The yellow color of the chromate in the sample gave an indication of the effectiveness. FeS slurry was taken from the chemical feed tank and when sufficient FeS had been added to react with all the metals in the sample, the yellow color disappeared. The required FeS dosage indicated by the jar test and the amount of FeS being introduced by the chemical feed system were noted and plotted on the graph reproduced in Figure VI. This illustrates the effect of the iron sulfide reservoir in the sludge blanket. Areas with diagonal lines represent excess supply of FeS, giving accumulation of FeS in the sludge blanket. Dotted areas represent excess demand for FeS over the feed rate, indicating consumption of active iron sulfide from the sludge blanket. Total detention time of iron sulfide in the sludge blanket is about 19 hours. High chemical operating costs are associated with excess feed of FeS. Adjustment to stoichiometric levels is important in

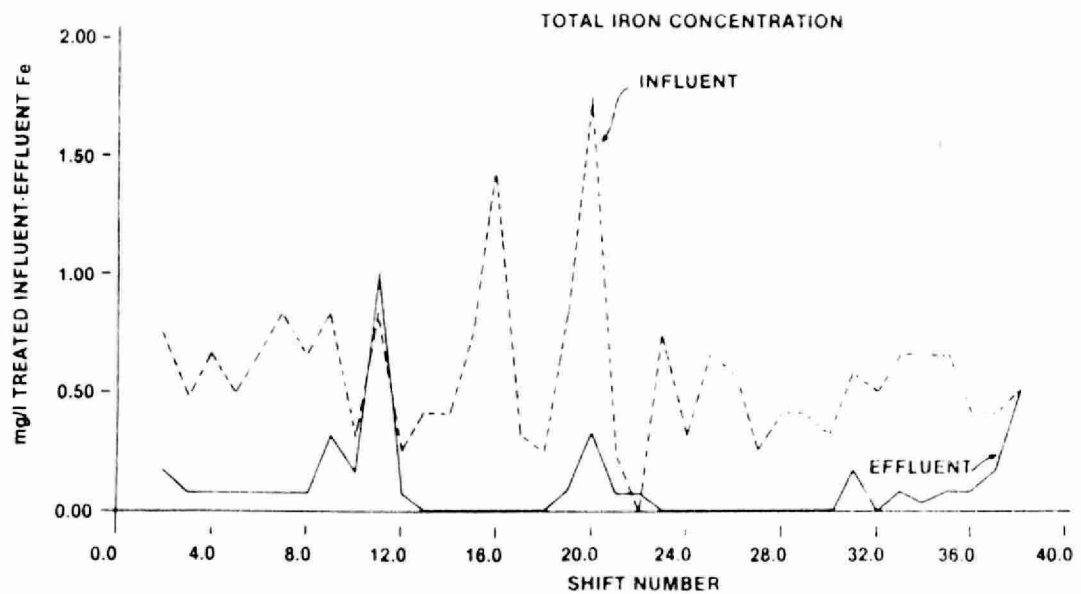
Fig. VI.



Effect of Variable Ferrous Sulfide Requirement on the Reserve Ferrous Sulfide Capacity of the Sludge Blanket as a Function of Time.

Note: X's are points where no jar test was made.

Fig. VII.



Average Concentration of Total Iron in Raw Influent and Filter Effluent as a Function of Time



controlling costs. The waste was analyzed for metals and the stoichiometric sulfide requirement obtained by calculation. Jar test sulfide demand averaged  $3.5 \times$  stoichiometric, although with greater operating experience closer control is expected to reduce iron sulfide consumption.

Sludge blowoff from the precipitator sludge concentrator is automatic, based on influent flow to the clarification unit. Amount of blowoff time is adjusted based on hydraulic load and suspended solids load. The height of the sludge blanket in the tube settlers allows estimation of the required time. Two sampling points are provided in the precipitator unit, one within the tube settlers and one 15 cm. below the tube settlers, to allow determination of the location of the sludge blanket.

Blowoff is collected in a sump and pumped through a filter press for dewatering. A polypropylene filter cloth is used. No precoat or body feed is required. Dewatered cake is disposed at a local landfill. The filter cake contains about 25% solids. Percentages of metals in the filter cake are given on a total dry weight basis in Table II.

Supernatant from the clarifier is pumped through a dual media anthracite-sand filter, which is equipped with an air scour to insure good cleaning during back washing. Good quality is

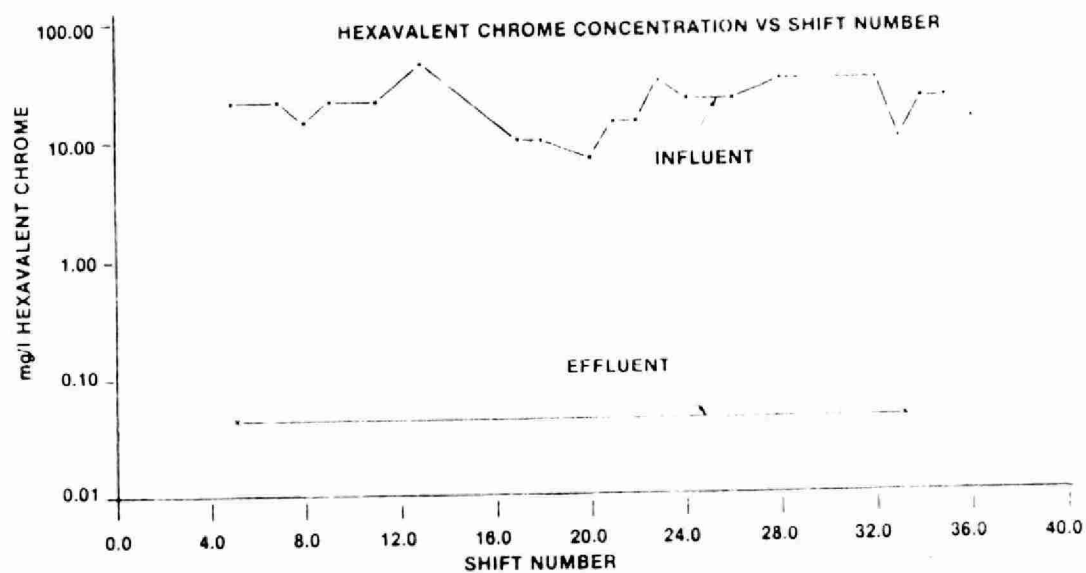
TABLE II  
FILTER CAKE COMPOSITION

| <u>Metal</u> | <u>% by Weight</u> |
|--------------|--------------------|
| Chromium     | 3.3% - 4.5%        |
| Iron         | 26.9% - 33.0%      |
| Copper       | less than .1%      |
| Zinc         | 3.7% - 4.1%        |
| Total Solids | 23.4% - 29.3%      |

possible without filtration, but it is often advisable to add a filter for prevention of accidental clarifier overflows.

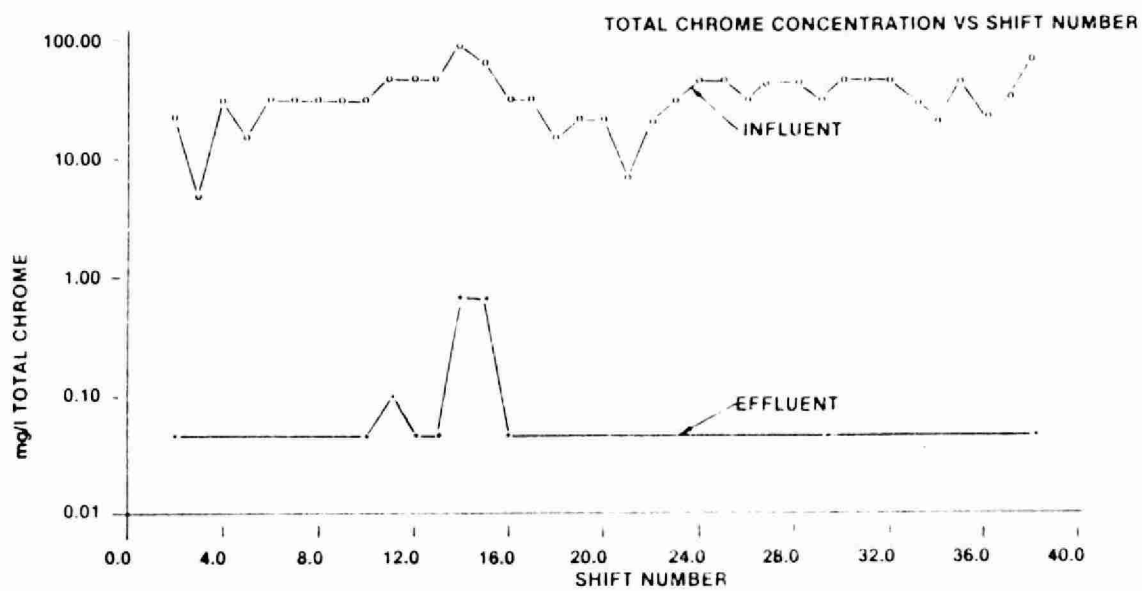
Filtered effluent from the treatment system at Holley Carburetor routinely produced metal concentrations lower than detectable by today's accepted analytical methods. Metal concentrations in the influent and effluent are shown in Figures VII, VIII, IX, X and XI.

Figure VIII.



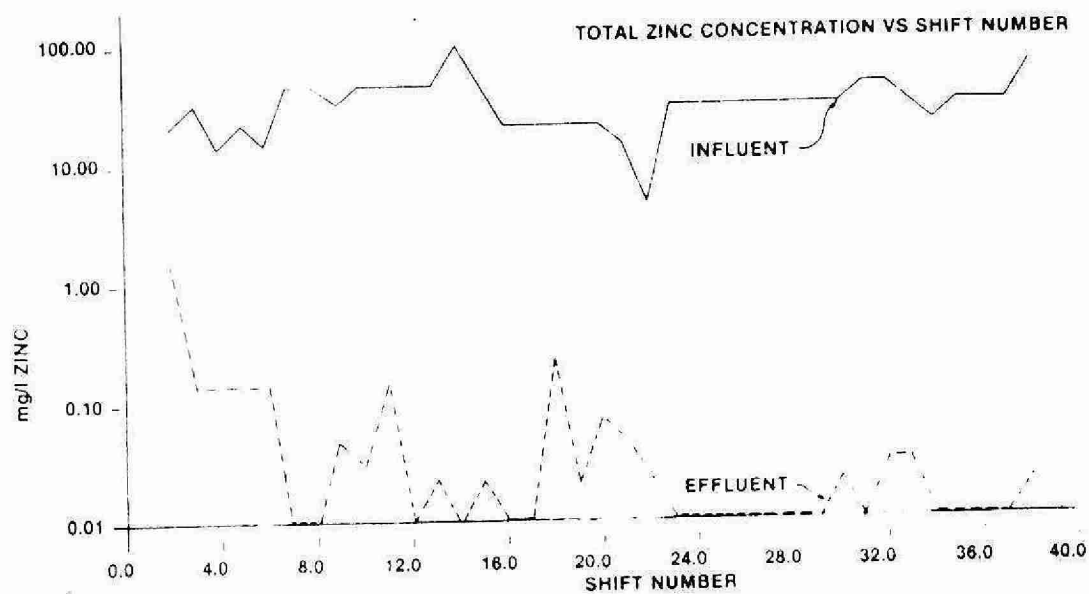
Average Concentration of Hexavalent Chrome in Raw Influent and Filter Effluent as a Function of Time.

Figure IX.



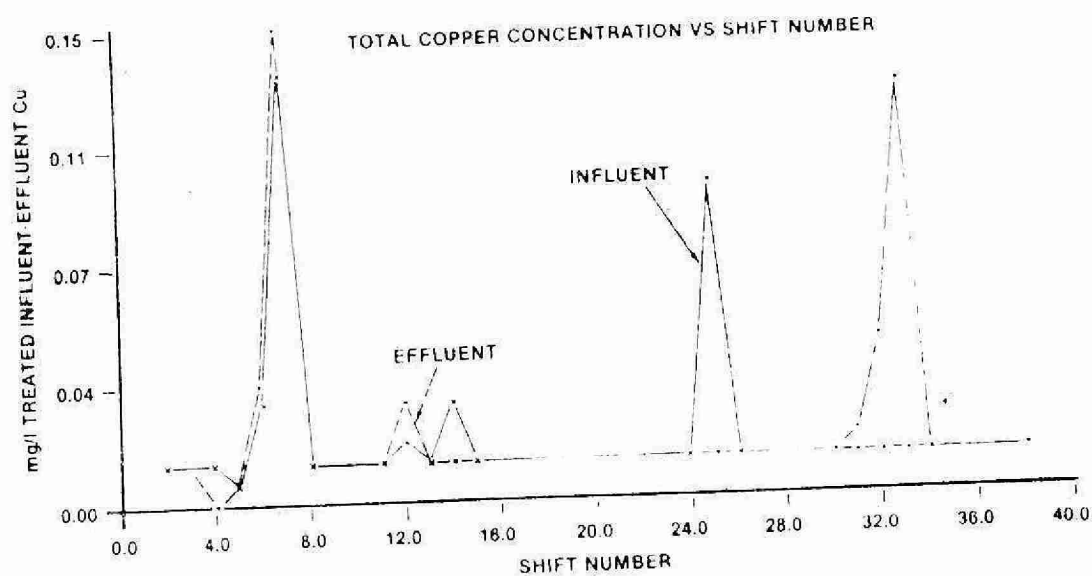
Average Concentration of Total Chromium in Raw Influent and Filter Effluent as a Function of Time.

Figure X.



Average Concentration of Total Zinc in Raw Influent and Filter Effluent as a Function of Time.

Figure XI.



Average Concentration of Total Copper in Raw Influent and Filter Effluent as a Function of Time.

## COST ANALYSIS

### Operating Costs

The yearly operating cost, excluding depreciation and licensing fees, for the treatment system at Holley Carburetor is outlined below. This cost results from charges incurred by operators, utilities and chemicals.

The estimated yearly operating cost, based on plant performance to date, is as follows:

1. Operators Salaries:

$$\begin{array}{rcl} \$10,800 \text{ per operator} \times 2 \text{ operators} & = & \$21,600 \\ + \text{ fringe benefits at 40\%} & = & \underline{8,640} \\ \text{Total Salaries} & = & \$30,240/\text{year} \end{array}$$

2. Electricity:

$$203.32 \frac{\text{kwh}}{\text{day}} \times 5 \frac{\text{day}}{\text{wk.}} \times \frac{52 \text{ wk}}{\text{yr.}} \times \frac{\$0.0191}{\text{kwh}} = \$1010/\text{year}$$

3. Water:

$$4162 \text{ m}^3 \times \$0.053/\text{m}^3 = \$220/\text{year}$$

4. Chemical:

$$\frac{\$14.69}{\text{shift}} \times 2 \frac{\text{shifts}}{\text{day}} \times 260 \frac{\text{days}}{\text{yr.}} = \$7639/\text{year}$$

5. Sludge Handling and Disposal Cost:

$$\frac{\$15}{\text{day}} \times 260 \frac{\text{days}}{\text{yr.}} = \$3900/\text{year}$$

Total Operating Cost is therefore:

$$\begin{array}{rcl} \text{Salaries} & = & \$ 30,240 \\ + \text{ Electricity} & = & 1,010 \\ + \text{ Water} & = & 220 \\ + \text{ Chemicals} & = & 7,639 \\ + \text{ Sludge Disposal} & = & \underline{3,900} \\ \text{TOTAL} & = & \$ 43,009/\text{year} \end{array}$$

The chemical cost is based on the following prices for chemicals delivered to Holley Carburetor Company, Paris, Tennessee:

Ferrous Sulfate,  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ , granular, 22.7 kg (50 lb) bags =  
\$0.149/kg (6.75¢/lb)

Sodium Sulfhydrate, NaHS, 70/72% flake, 181.4 kg (400 lb) drums =  
\$0.584/kg (26.5¢/lb)

Hydrated Lime, 93%,  $\text{Ca}(\text{OH})_2$ , 22.7 kg (50 lb) bags = \$0.1025/kg (4.65¢/lb)

Polyelectrolyte, cationic guar gum, 45.4 kg (100 lb) drums =  
\$2.32/kg (105¢/lb)

From the above costs, it is seen that the operator's salaries account for 70% of the yearly operating cost. This cost would, of course, be the same for any system requiring operator attention over a period of two shifts per day. The utility costs are estimated from actual figures obtained from Holley Carburetor Company.

Chemical cost has been determined by averaging the chemical usage over the last 16 shifts of the demonstration test. The first 22 shifts were eliminated from this cost estimate. During this first period, the operation of the system was not yet at steady state conditions and is considered not representative of normal operating conditions. Data which was collected prior to the 23rd shift represents unstable operation due to normal trial and error of start-up and operating training.

It is assumed that the real chemical requirement can be reduced from the presented \$14.69 per shift by at least 10 percent. This assumption is based on the existing evidence that the jar test results for ferrous sulfide demand, without using sludge recirculation, are in excess of the real requirement by at least 10 percent.

The average actual cost per kilogram of hexavalent chromium and zinc treated based on the final 16 shifts of demonstration was \$5.72/Kg. If we can estimate that the real chemical requirement is only 90% of the actual usage, due to the FeS excess dictated by jar tests, the cost of hexavalent chromium and zinc removal is reduced to \$5.15/Kg.

#### CAPITAL COSTS

At Holley Carburetor, due to construction difficulties (primarily quicksand), underground tanks for neutralization and equalization were built above-grade and therefore were more expensive. Estimated cost for underground tanks is approximately \$16,000 as opposed to the actual \$48,000 cost. Table III shows the actual costs incurred, exclusive of taxes.

#### SUMMARY AND CONCLUSIONS

This demonstration was performed to verify the operational practicality and quality of performance of a new sulfide precipitation process, Sulfex, for removal of heavy metals from metal finishing wastewaters. In addition, operational data was gathered for an economic comparison of a sulfide precipitation process with a conventional hydroxide precipitation process.

A study covering 28 days of operation was performed by Holley Carburetor Division of Colt Industries in conjunction with the



## SUMMARY AND CONCLUSIONS (Continued)

Permutit Company at the carburetor manufacturing plant in Paris, Tennessee. At this plant, Udyllite processes are used for chromate coatings of aluminum and zinc carburetor castings before assembly. In addition to chromium and zinc, the full scale waste treatment system is used to remove suspended material such as aluminum, iron and phosphate precipitates from the plant's combined metal finishing process wastewater. Major steps in the system are: utilization and neutralization of raw wastewaters, precipitation of metals and sedimentation of resulting suspended solids, polishing of settler effluent with dual medial filtration and final dewatering of settled sludge with a filter press.

The study consisted of a complete monitoring program of the system operation. Variations in the raw wastewater and treated effluent quality were determined by methodical sampling and analyses. Jar tests were performed several time daily to observe wastewater treatability and chemical requirements. The relationship between the jar test results and simultaneous full scale system operation was assessed as a means of controlling the chemical additions to and solids removal from the system. Operational parameters such as pH values, flow rates, chemical consumption, solids settling characteristics, filter pressure differentials and filter cleaning cycles were monitored regularly. From this data, the operational criteria and economics have been determined.

## RESULTS AND CONCLUSIONS (Continued)

Results show that the metals and suspended solids were removed to levels well below the City of Paris Sewer System limitations and the State of Tennessee's guidelines for indirect discharges to sewer systems. It was demonstrated that jar tests are a valuable tool for maintaining good control and more economical operation of the system. A dewatered sludge was produced as a compact dry cake that released easily from the filter press cloth without use of conditioning agents. The solids were disposed of in a city landfill site. No hydrogen sulfide odor was detected from the reaction process, the treated effluent, or the solid waste produced. Sulfex was shown to be an economical, as well as effective treatment process for this type of wastewater.

Introducing the TAGA 3000 - A Unique Mobile Air  
and Stack Gas Monitoring System  
by

N.M. Reid, Vice-President, Research & Development  
Sciex Inc., Thornhill, Ontario

The air resources branch of the Ontario Ministry of the Environment has recently acquired a new and unique mobile air monitoring unit to collect air quality data and provide on-the-spot measurements.

The mobile TAGA™ 3000 (Trace Atmospheric Gas Analyser, model 3000) will give Environment Ontario the most advanced and sophisticated means available to monitor atmospheric pollutants.

The new mobile monitoring vehicle is 26 feet long and outfitted with two six-kilowatt generators, air conditioning, a dedicated computerized data handling system, and a meteorological tower which can be raised to measure wind speed and direction, temperature, barometric pressure, and humidity, and which may also serve as an inlet for air samples to be analyzed.

The instrumentation of TAGA™ 3000 enables monitoring of a wide spectrum of organic and inorganic substances. Its self-contained computer and data acquisition system automatically record air quality data which can be rapidly compiled into printed reports.

The TAGA™ 3000 system is the first commercial system designed to realize the full potential of atmospheric pressure chemical ionization (APCI) coupled with mass spectrometric detection (APCI/MS). The combination produces an instrument of unusual sensitivity and selectivity. The system was initially developed by the Institute for Aerospace Studies at the University of Toronto, and further developed, and manufactured, by SCIEX INC. of Thornhill, Ontario.

Instantaneous determination of gaseous ultratrace pollutants in ambient air can be carried out with this system by virtue of this combination of hypersensitivity, almost instantaneous response, freedom from memory effect, and sophisticated computer control. These attributes, together with the fact that the system has been incorporated into a mobile laboratory, provide a new approach to the monitoring of ambient air pollutants.

The TAGA™ 3000 system, in fact, represents a breakthrough in atmospheric information gathering. It has multiple trace monitoring capability and produces easy-to-interpret results from complex mixtures of gaseous substances in ambient air. Instantaneous measurement eliminates most of the former sample work-up requirements, and extra laboratory work. All traces are identified by their molecular mass, and most chemical compounds can be detected in the range of parts per billion and parts per trillion. It can observe the changing pattern of trace components continuously, and generally provides instant analysis of air quality that hitherto was not feasible.

The first half of this presentation will give a technical description of the TAGA™ 3000. The remainder of the presentation will be devoted to describing some of the systems capabilities of specific interest to the attendees of this conference. For example, the system is able to collect, analyze, and detect a miniscule trace amount of PCB (polychlorinated biphenyl) within a period of one minute. This breakthrough capability replaces traditional techniques which require an 8 to 24-hour collection period followed by a lengthy analysis procedure in a laboratory.

Other applications for the new mobile unit with a TAGA™ 3000 system that will be covered include:

- Isolation and identification of sources, such as fugitive emissions;
- Fast surveys of background levels of selected contaminants throughout a wide geographical area;
- Checking the effectiveness of industrial pollution abatement devices, and monitoring occupational environments;
- Stack gas monitoring and plume tracking, including the generation of ground level concentration isopleths, or profiles;
- Emergency response to hazardous spills.

## PERPETUAL CARE FOR WASTE MANAGEMENT FACILITIES

### INTERIM REPORT

#### Preamble

The Minister's seven-point program to deal with liquid and hazardous industrial wastes referred to the need for "perpetual care" for disposal facilities. Arising out of this, a Ministry Task Force was set up early in 1979 to investigate the need for such a program and to prepare a report, with recommendations on the measures required and their means of implementation.

Members of the Task Force were drawn from the Waste Management Branch, the Environmental Approvals Branch, the Legal Branch, and the Central Regional Office of the Ministry.

The basic premise of the terms of reference was that in order to fully protect the environment, the individual, and those sectors of public and private enterprise who are involved in waste management, an assured source of funding, and authority to make prompt use of this funding if necessary, is required both during the lifetime of a waste disposal site or a waste management facility and in the long term, after site closure.

#### General Background

In the opinion of the Task Force, the requirements imposed under the Environmental Protection Act on the location and operation of a landfill disposal site

and other waste management facilities, both for solid and liquid wastes, will generally ensure that public health and safety concerns are met, and that minimal off-site contamination results.

However, prior to 1971, essentially no controls were exercised over the disposal of waste, and even after the introduction of the Waste Management Act, several years were required to build up and organise an effective system to implement the legislative controls.

Apart from this, the technology of waste management is comparatively new, and the past decade has seen very rapid progress in our knowledge of the problems and of the technology needed to solve these problems.

From this, two conclusions can be drawn:

First, a large number of disposal sites were established, and in many cases closed down and forgotten before controls and proper records were required. Some of these may require action to prevent, or remedy, problems of gas or leachate production. However, it will be difficult to pin down responsibility and even more difficult to obtain remedial action, or compensation for any damages that may occur.

Second, the "state of the art" is unlikely to have reached as yet its final form. Consequently, despite the most sophisticated precautions, problems could still arise due either to inadequate operation, unforeseen contingencies, or to accidents, both during the lifetime of the site and in the long term, perhaps many years after the site has ceased to be used.

Although no serious hazards resulting from leachate have been identified, in Ontario, in a number of instances contamination of ground or surface waters has occurred. Gas production has, up to the present, been a more serious problem, and methane gas moving laterally beyond the boundaries of landfill disposal sites has been measured in explosive quantities on adjacent property. Explosions have in fact occurred in several instances.

There is no doubt that a potential problem does exist, though it appears unlikely that incidents such as a "Love Canal" will be uncovered in Ontario.

Methods of identifying potential problem areas, and the development of any remedial measures necessary, are already being dealt with by the Ministry. The purpose of this Task Force is essentially to recommend measures which will ensure that adequate funds are available for the proper operation and closure of disposal sites, for any remedial measures necessary, and to provide compensation for any damage that may be incurred even if the legal responsibility is not clear.

#### Funding Sectors

The Task Force has concluded that measures are required in three major sectors with differing characteristics:

- 1) To ensure that funding is available for use during the operation and closure of a disposal facility, and for subsequent monitoring and maintenance;
- 2) To provide off-site protection for third parties during this period; and
- 3) For "perpetual care" and for any contingencies not covered by other measures.

It should be noted that precedents have already been set to some degree in all of these areas.

For example, the present statute requires persons, other than municipalities, to establish financial responsibility by posting security, to ensure that the operation will be conducted properly. Although this provision was not found workable, and has not been used, in a number of instances an equivalent result has been achieved by imposing conditions on certificates of approval requiring that funds be established for specified purposes.

Another example is the Deep Well Disposal Fund set up under the legislation, which is built up by a surcharge on the volume of waste discharged into a deep well, and which can be used to provide alternative water supplies in case an existing supply is rendered unusable by contamination from the disposal well.

In addition, the new spill legislation now under consideration is a parallel approach with similar though more limited objectives.

#### General Principles

Before discussing in detail requirements in each of the three sectors, some of the principles upon which the approach is based should be examined.

The Task Force has concluded that any measures introduced should apply not only to liquid and hazardous industrial waste, but also to solid municipal waste. Obviously, the potential risks involved in the case of municipal waste are limited, but as previously noted, they cannot be ignored and it is considered that all types of



waste should be covered. It should also be noted that the situation in Ontario is very different from that in the U.S. whose proposed legislation deals only with liquid and hazardous wastes. The number of liquid and hazardous disposal facilities in Ontario will be limited. Consequently, if only these were to be considered, it would be preferable to deal with them on an individual case-by-case basis. However, if this approach were taken, it would be difficult to set up a realistic fund for perpetual care and contingencies, except by government funding, or a general surcharge on all industries producing such wastes.

In the view of the Task Force the better approach is to include all types of waste, recognising that public concern makes only a limited distinction between them as a cause for opposition to the establishment of facilities.

A second principle which must be emphasized is that the availability of remedial funding should have no direct bearing on decision making with regard to the approval process. In other words, there must be no question of any relaxation of the standards required for locating and operating a site because of these measures.

Finally, it was concluded that the sector three funding for perpetual care should be limited, as far as possible, to long term protection commencing at some reasonable period after site closure, and for emergency use. In the latter case, expenditures would be considered recoverable from the party responsible, through legal action if necessary.

## Sector 1 Funding - Operational

This is intended to ensure that funds are available for immediate use for all operational costs, including day-to-day operation, monitoring, remedial measures, closure, and continued monitoring and the provision of any remedial measures found necessary for some reasonable period after closure.

Although, as has been pointed out, in certain cases the Director in issuing a certificate of approval has imposed conditions on the certificate requiring site-specific funds or security to be established for particular purposes, his ability to do so could be questioned on the basis that the statute already makes specific provisions for such funds or security and therefore the Director cannot impose different conditions. This issue has not yet been raised in the courts or otherwise, so no firm opinion can be given on the chances of the success of a person objecting to the validity of such a condition.

Two of the chief reasons for the difficulty in applying the present statutory provisions are that the money or security must be provided by the operator before he obtains a certificate of approval, which in many cases is a financial impossibility if a realistic amount is to be secured. The requirements for each site will vary depending on its location, the type of soil, the type of waste, the proposed method of operation, and many other factors which cannot be sufficiently determined in advance for a regulation of general application to be developed.

In addition, the present statute does not apply to municipalities and the smaller municipalities may have difficulty in obtaining funds to implement proper operation

of a site, or proper closure and the development of a satisfactory new site. The difficulties would be alleviated if they could be required to establish a fund which could be built up over a period of time to cover the necessary expenses.

Specific purposes of such a fund would be:

- 1) To provide for capital expenses to be incurred in the future such as the installation of gas or leachate control and treatment systems;
- 2) To provide for the costs of closure of a site, including the provision of cover material and the maintenance of the cover until soil settlement has stabilized;
- 3) To cover the costs of liability insurance premiums for a period of time (say five years) after closure;
- 4) Operating leachate and gas monitoring, control, and treatment systems after closure.

As the expenses for which a fund for a site is established will be uncertain at the time it is established, there should be provision to review and modify the amount of the fund from time to time.

It should be possible to build up the fund or part of it over a period of time during the life of the site to reduce the need for heavy up-front expenditures.

Further consideration is required on the means of administration of these site-specific funds. However, it does not appear necessary that they should be administered by the Province as long as there is some mechanism by which the Province can be assured that they in fact exist and are being maintained properly.

The following statutory provisions appear necessary to implement sector 1 funding:

- 1) Authority to make regulations requiring different classes of site or systems to post security, or establish funds, or both;
- 2) Authority for regulations and certificates of approval to prescribe amounts, terms and conditions for such security and funds on the basis of classes of site or system (regulations) and for individual sites or systems (regulations or certificates of approval);
- 3) Requirement by regulation for filing evidence of compliance with Director;
- 4) Authority to prescribe by regulation or certificate of approval who will hold security or funds;
- 5) Authority, if the funds are held by the Province, to prescribe interest rates;
- 6) Authority by regulation or certificate of approval to prescribe terms and conditions for repayment of funds or release of security;
- 7) Authority for the Director to spend funds or require that they be spent, or delivered to him for such purpose if the operator does not carry out necessary work;
- 8) Authority for regulations or certificates of approval to specify form of security;
- 9) Authority for regulation to require owners or operators of various classes to belong to an association which would be responsible for administering funds or security. A similar provision may be required under sector 2 funding, and the same associations could be involved in both cases.

Since sector 1 funding is highly site-specific, it is envisaged that proponents of a proposed site would include sector 1 funding proposals as part of their applications for a certificate of approval. Consequently, funding proposals would be presented at

an environmental hearing with the opportunity for public input, and would be assessed by the Board, and by the Director in due course.

## Sector 2 Funding - Liability Insurance

To achieve the objectives for which the Task Force was set up, it is necessary to ensure that operators are financially stable and therefore able to operate their sites properly and meet their obligations to the environment and to adjacent property owners. One cause of financial instability could be claims made by persons whose interests are damaged by the operation. Protection against this cause of financial instability is generally obtained by liability insurance, which also provides a more or less direct protection to third parties who make claims. These can be persons who suffer personal or property damage as a result of improper operation, or a person who has to take action pursuant to a statute to clean up the results of improper operation.

Generally, the risks that can be protected by insurance are subject to three major qualifications:

- 1) Insurance policies generally have a deductible. The deductible serves two purposes. It eliminates the payment of premiums to cover the cost of small claims which can be expected to occur on a relatively frequent basis, and which the operator should be able to meet as part of the regular costs of doing business, and also to cover the administrative costs of the insurer having to settle the numerous small claims;

- 2) Certain risks are not covered, either because the insurance covers a list of specified risks and the list is not all-inclusive, or because it is written as all-risk

insurance with specified exclusions. Two principal reasons for such limited coverage are that some risks may be ordinarily covered under other policies of insurance, and other risks may be so hazardous that the premium would be inordinately high if they were covered;

3) Insurance policies have a maximum amount payable which may be determined on one or more of the following bases: - the type of loss; per time period of the policy; or per incident.

These limits are imposed for two reasons, the difficulty of finding persons willing or financially able to underwrite the level of risk, and the high level of premium which it could be necessary to pay even if such a person were found.

If liability insurance is imposed as a statutory requirement, several benefits can arise:

- 1) The deductible can be kept to a reasonable level;
- 2) The risks that are covered can be kept reasonably broad;
- 3) Minimum amounts of coverage can be kept at a reasonably high level.

It should be noted that insurance companies in Ontario have generally shown reluctance to write comprehensive liability coverage that does not exclude most environmental risks. However, this attitude might change if a large number of such policies were to be written.

A fourth type of benefit which can be achieved by a statutory requirement of coverage is that a third party who has a claim can be given a claim directly against

the liability insurer. Unless different provision is made by statute, an injured third party first has to successfully press his claim against the persons responsible for the loss, and then he may still be faced with a refusal of the insurer to pay the claim perhaps on the basis that the insurance policy is not valid or is not enforceable because of some act by the insured person. Automobile liability insurers by statute cannot raise as a defence against paying a successful third party a matter that they could raise against their own insured, except for that part of the claim in excess of the minimum required coverage.

An indirect advantage of insurance is that if the government is to assume liability for damages and costs beyond the means of an operator and sets up an account funded by operators for such purposes, the fund may be maintained at a smaller size, and payments by operators kept at a lower rate if a substantial part of the risk is underwritten by private insurance.

One group of insurers has indicated that if a particular type of coverage were required by statute, they would write a policy to give the required coverage provided a reasonable number of policies were to be written. Other information received indicates that:

- 1) they would be willing to issue policies which provide direct protection to third parties;
- 2) policies could provide coverage for losses occurring up to five years after the last premium was paid;
- 3) a single policy could cover a number of different interests in an operation, for example, a site operator, the owner of the site, and the municipality using the site for the disposal of its waste;

4) the policy could be transferrable to a new operator or owner, subject to approval by the insurer.

It was also indicated that the premiums for the policies would be substantially higher if all operators were not required to have insurance, and especially if only a small part of the industry such as the haulers of liquid industrial waste which is considered to be particularly hazardous were required to insure. The insurers would also retain the right to refuse to issue policies in individual cases and would assess premiums on an individual basis.

It would be difficult to have insurance policies issued if all persons who would eventually be required to obtain insurance were required to obtain it at the same time. Consequently, detailed procedures would include methods of phasing in different types of disposal facilities, giving priority first to liquid and hazardous waste facilities and next to the larger municipal waste disposal sites.

As pointed out, it would be necessary to provide by statute for insurance of the type suggested above. Some of the provisions should be direct statutory requirements; the statutes should permit others to be established by regulation or condition in certificates of approval.

The statute should:

- 1) require liability insurance to be obtained by operators, owners or others with respect to waste disposal sites and waste management systems;
- 2) provide for implementation of this requirement by dates set by regulation for different classes of existing sites and systems;



- 3) provide for regulations to set dollar limits, risks to be covered and permissible exclusions of risks by class;
- 4) permit higher limits or broader risks to be imposed as conditions in certificates of approval;
- 5) require that the Director of Approvals be notified if insurance coverage is cancelled;
- 6) provide direct protection for third parties;
- 7) provide for regulations to require proof of insurance;
- 8) provide for regulations requiring certain operators to belong to associations and prescribing certain requirements for such associations;
- 9) provide for regulations to prescribe, and permit certificates to prescribe periods after closure for which insurance must be kept in force.

As previously discussed, the availability of insurance of this type, the maximum amount payable on the policy and the premiums to be paid will be significant factors in determining the details of other funding sector requirements, and particularly the amount of surcharge against operators for the perpetual care funding.

Recognising this, the Task Force has arranged with a company providing environmental impairment liability insurance of the type required to develop premiums for two types of site; a large municipal landfill site, and a liquid and hazardous waste disposal facility.

This will require an engineering evaluation of the facilities by the insurance company's consultant. It has been agreed that this study will be funded by the Ministry through the Provincial Lottery. It has also been agreed that since in this instance the principal interest of the Ministry is in determining the availability of

policies, and the cost of premiums, the details of the consultant's evaluation will be kept confidential.

### Sector 3 Funding - Perpetual Care

A perpetual care fund for waste disposal would cover risks not met by an operator or an operator's insurance for present and future operations, and for old operations now no longer in use for waste disposal. The fund would also be available to provide immediate action, or payment of damages, where it appeared there would be delay in an operator or his insurer responding.

This fund would be similar to the waste well disposal fund, which would probably be collapsed into the new fund.

The fund should be able to recover its disbursements from the persons ultimately responsible, that is, owners and operators, and from persons who have caused damage for which they are responsible at common-law or by statute (such as the proposed spill legislation). However, it appears desirable to consider putting a limit on the period after site closure when reimbursement could still be sought.

Mechanisms for having payments made into the fund, and for making payments out of the fund remain to be determined.

Payments out of the fund could be left as discretionary in the hands of the Minister or Director or placed under a board established for such purposes, but it appears preferable to give persons a right to payment from the fund, enforceable in court if the administrator will not agree to the liability of the fund to make a payment or on the size of the payment.

An important aspect which will be further examined is the development of criteria to be used by the administrator in determining whether payments should be made and the amount of payment. For example, it would appear desirable to exclude, or strictly limit, liability for compensation for the alleged devaluation of property adjacent to a disposal facility. The Task Force is concerned that the existence of a government 'blank cheque' does not lead to inflated claims for damages, or to an unreasonable expansion of the concept of damage.

The Task Force will examine how payments are to be made into the fund and on what basis, for example whether the surcharge should vary depending on the type and the toxicity of waste, and whether it should be based on the weight if scales are available or on a per-capita basis if they are not. The site operators would be made responsible for providing the necessary data, and in this connection other initiatives now underway in the Ministry may be of considerable assistance in reducing the administrative workload imposed on the administrator of the fund. An EDP system is under development for waste sites which could be modified to incorporate perpetual care fund requirements. Also, a municipal waste management information system is now being tested which might be utilized as a data recording mechanism by municipalities, and extended with modifications to include private operations.

Generally, it should be noted that the number of claims against the fund and therefore the necessary size of payments required into the fund and the amount of resources spent in administering it will be reduced if sites and systems are properly operated and closed. Therefore a sound liability insurance program, and the funding of operating requirements are closely related to the establishment of the fund.

The question of resources required will be examined by the Task Force, but it would appear that providing an EDP system can be adapted to handle the data these will be limited. Some work, such as detailed evaluation of claims, might have to be handled by consultants under contract with fees paid from the fund.

The statutory amendments necessary to provide for the fund include:

- 1) Establish the fund;
- 2) Collapse the waste well disposal fund into it;
- 3) Provide for interest (by order in council) on balances in the fund;
- 4) Establish different rates, by regulation, for different types of operation;
- 5) By regulation provide for payment and collection of rates and interest on overdue payments;
- 6) Prescribe the claims for which the fund would be available with an ability to extend by regulation (these would include clean-up expenses of crown and perhaps others);
- 7) Establish liability to reimburse fund;
- 8) Enable regulations to be made limiting liability to reimburse, both excluding claims for low amounts and putting ceilings on claims;
- 9) Provide "subrogation" procedures as in recent proposed spill legislation procedures;
- 10) Enable regulations to be passed limiting liability of fund by dollars and risk;
- 11) Enable interest bearing advances to be made to fund by Treasurer, in case payments in excess of balance in fund at any time have to be made;
- 12) Authorise fund to sue in Ontario a non-resident of Ontario.

A significant point still to be established is the maximum amount at which the funds could be set, and the period of time considered reasonable by which this amount is to be developed from the surcharge on operators. A further point to be considered is the action to be taken when the fund reaches this required amount. Options are for example to relieve operators of existing sites of the requirement for payment, or to make provisions for the use of the surplus to improve waste management facilities which might include subsidization of processing plants which would reduce the risk associated with disposal sites.